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IN THE NAME OF ALLAH,
MOST GRACIOUS, MOST MERCIFUL

kingdom of Saudi Arabia
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***** Saudi Economic Association (SEA)- King Saud University.***

Journal of Economic Studies

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Journal of Economic Studies

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- *The list of the Arabic references must be translated into English and added after the list of the Arabic references and before the English references (titled: (Arabic References).*

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Insights into Saudi Arabia's Economic Transformation: Renewable Energy, FDI, and GDP Dynamics

Nagwa A. Abdelkawy [(1)] Abdullah S. Alshamery [(2)] Munira Z. Aljohar [(3)]

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Abstract: This study analyzes the dynamic interplay among key economic indicators—Foreign Direct Investment (FDI), Exports (Exp), Government Consumption Expenditure (GC), and Renewable Energy consumption (RE)—and their effects on Saudi Arabia's Gross Domestic Product (GDP) from 2000 to 2021. Using a comprehensive econometric framework that includes Ordinary Least Squares (OLS) analysis, Vector Autoregression (VAR) models, and Granger Causality tests, this research uncovers the economic drivers shaping Saudi Arabia's Vision 2030. The study finds that FDI and renewable energy consumption significantly predict GDP growth. While many studies have explored the impact of various economic indicators on growth, definitive findings on their predictive relationships with GDP growth in Saudi Arabia are limited. This study fills this gap by highlighting significant predictive relationships, particularly how FDI and renewable energy consumption can drive GDP growth. The results suggest that policies promoting FDI, and renewable energy investments could greatly enhance Saudi Arabia's economic development, aligning with Vision 2030. A novel aspect of this research is its identification of structural changes in economic relationships following major renewable energy policy initiatives introduced in 2019-2020, providing empirical evidence of policy impacts on economic dynamics. These findings not only contribute to academic discussions on economic diversification but also offer actionable insights for policymakers to optimize Saudi Arabia's transition towards a more diversified and sustainable economy.

Key words: Economic Development, Gross Domestic Products (GDP), Foreign Direct Investment (FDI), renewable energy consumption, Saudi Arabia, VAR model, Granger Causality.

رؤى حول التحول الاقتصادي في المملكة العربية السعودية: ديناميات الطاقة المتجددة والاستثمار الأجنبي المباشر والناتج المحلي الإجمالي

نجوى أمين عبد القوي [(1)] عبد الله سلطان الشمري [(2)] منيرة زكي الجوهر [(3)]

(قُدِّم للنشر 1445/11/10هـ – وقُبِل للنشر 1446/01/22هـ

المستخلص: تقدم هذه الدراسة تحليلاً للتفاعل بين المؤشرات الاقتصادية الرئيسية مثل الاستثمار الأجنبي المباشر، الصادرات، الإنفاق الحكومي، واستهلاك الطاقة المتجددة وتأثيرها على الناتج المحلي الإجمالي في السعودية من 2000 إلى 2021. باستخدام إطار اقتصادي شامل يتضمن تحليل المربعات الصغرى العادية، نماذج الانحدار الذاتي المتجه، واختبارات التسبب في غرانجر، تكشف الدراسة عن رؤى حول المحركات الاقتصادية التي تشكل رؤية السعودية 2030.على الرغم من وجود العديد من الدراسات التي تبحث في تأثير المؤشرات الاقتصادية المختلفة على النمو الاقتصادي، إلا أن الأدبيات حول المملكة العربية السعودية تفتقر إلى نتائج قاطعة بشأن العلاقة التنبؤية بين هذه المتغيرات ونمو الناتج المحلي الإجمالي. تسد هذه الدراسة هذه الفجوة من خلال الكشف عن علاقات تنبؤية هامة، وتسلط الضوء على الدور الحاسم للاستثمار الأجنبي المباشر واستهلاك الطاقة المتجددة في التنبؤ بنمو الناتج المحلي الإجمالي. وتشير النتائج إلى أن السياسات التي تشجع الاستثمار الأجنبي المباشر واستثمارات الطاقة المتجددة، يمكن أن تعزز وبشكل كبير التنمية الاقتصادية في المملكة العربية السعودية، بما يتماشى مع رؤية 2030. إن الحداثة الرئيسية في هذا البحث هي تحديده للتغيرات الهيكلية في العلاقات الاقتصادية بعد المبادرات السياسية الرئيسية للطاقة المتجددة التي تم تقديمها في 2019–2020، مما يوفر أدلة تجريبية على تأثير السياسات على الديناميات الاقتصادية. وتقدم هذه النتائج رؤى عملية لصانعي السياسات بهدف نقل المملكة نحو اقتصاد أكثر تنوعاً واستدامة. يساهم البحث في إظهار أهمية الاستثمار الأجنبي المباشر والطاقة المتجددة والحاجة إلى استراتيجيات اقتصادية معدلة تستجيب للاتجاهات المحلية والعالمية في الاستدامة.

الكلمات المفتاحية: التنمية الاقتصادية، الناتج المحلي الإجمالي، الاستثمار الأجنبي المباشر، استهلاك الطاقة المتجددة، المملكة العربية السعودية، نموذجVAR ، السببية المتقدمة (جرانجر)..

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1.Introduction

Saudi Arabia is at a crucial point in its economic development, driven by the ambitious goals of Vision 2030. This national agenda aims to diversify the economy and reduce reliance on oil revenue, requiring significant changes influenced by factors like Foreign Direct Investment (FDI), exports, government spending, and renewable energy. These factors are essential in shaping the economic landscape, presenting both opportunities and challenges in moving toward a more diversified and sustainable economy.

Historically, Saudi Arabia has heavily depended on oil exports, which constituted a significant portion of its GDP. However, recent years have seen a concerted effort to attract FDI to diversify the economy. John Dunning's Eclectic Paradigm (Dunning, 1980) explains this shift, highlighting how ownership, location, and internalization advantages drive FDI. According to the Ministry of Investment, FDI net inflows to Saudi Arabia increased by 21% year-on-year, reaching approximately SAR 105.2 billion in 2022 (Figure 1). This growth placed Saudi Arabia tenth among G20 countries for FDI net flows in 2022 and 16th for FDI balance (Saudi Central Bank, 2023). Key sectors attracting FDI include technology, renewable energy, and infrastructure. Renewable energy, especially solar and wind power, has also become a key focus of Vision 2030. The Diffusion of Innovations Theory by Everett Rogers (Rogers, 1962) explains how new technologies spread, aligning with the government's efforts to promote renewable energy and achieve widespread adoption. In 2019, major renewable energy projects like the Sakaka solar power plant and the Dumat Al Jandal wind farm were launched. The installed capacity of renewable energy in Saudi Arabia has been steadily increasing, with the government aiming to generate 50% of its electricity from renewable sources by 2030 (Vision 2030, n.d.).

The Structural Change Theory, developed by Arthur Lewis and expanded by Hollis Chenery (Lewis, 1954; Chenery, 1979), emphasizes the importance of moving from an oil-dependent economy to a diversified one. This theory stresses the role of investment in human capital, infrastructure, and technological innovation in driving economic transformation. For Saudi Arabia, this shift involves reducing dependence on oil revenues and investing in renewable energy and high-tech industries to achieve sustainable economic growth.

Despite these efforts, there remains a gap in the comprehensive analysis of the combined effects of FDI and renewable energy consumption on Saudi Arabia's economic growth. Previous research has not definitively addressed the predictive relationships between these economic indicators and GDP growth. This study aims to fill this gap by providing new insights through advanced econometric models, revealing the dynamic relationships between FDI, renewable energy consumption, and GDP growth in Saudi Arabia. One novel contribution of this research is identifying structural changes in economic relationships following renewable energy policy initiatives, which previous studies have not extensively explored.

Saudi Arabia's economic transformation, guided by Vision 2030, aims to diversify the economy and reduce dependency on oil revenues. This transformation requires a deeper understanding of the interplay between FDI and renewable energy consumption, both critical drivers of sustainable economic growth. While significant progress has been made in attracting FDI and promoting renewable energy projects, a gap remains in comprehensively analyzing their combined effects on the economy. This study seeks to fill this gap by using advanced econometric models to explore the dynamic relationships between FDI, renewable energy consumption, and GDP growth in Saudi Arabia.

This study aims to achieve three primary objectives crucial for understanding and supporting Saudi Arabia's economic transformation under Vision 2030:

Firstly, analyze how FDI inflows contribute to GDP growth, informed by the Eclectic Paradigm. This objective is essential for informing policies that create a more favorable investment climate. Such policies could enhance regulatory frameworks and offer incentives to attract foreign investors, supporting economic diversification efforts.

Secondly, determine the extent to which renewable energy consumption influences economic performance and sustainability, guided by the Diffusion of Innovations Theory. The results from this assessment could advocate for policies that provide financial

incentives for renewable energy investments and reduce barriers to such investments.

Thirdly, explore the interactions between FDI, renewable energy consumption, and other key economic indicators, such as government consumption and exports, to understand their combined effects on Saudi Arabia's GDP from 2000 to 2021. Understanding these interactions is crucial for developing integrated economic strategies that promote both FDI and renewable energy as pillars of economic growth.

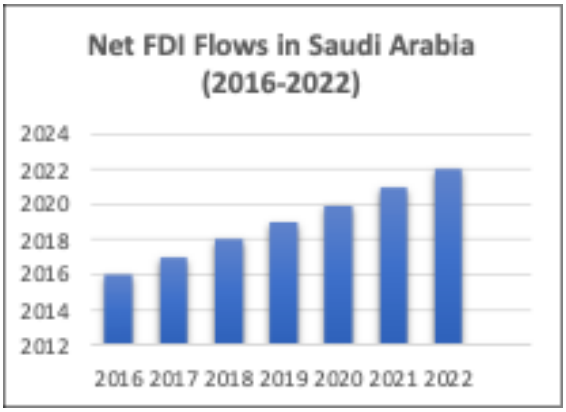
The study's outcomes aim to influence policy-making by highlighting the importance of FDI and renewable energy consumption. For example, the government could introduce incentives for foreign investments in renewable energy and streamline FDI regulatory frameworks.

This study significantly contributes to the literature on Saudi Arabia's economic development by identifying structural changes due to renewable energy policies, employing comprehensive econometric analysis, and providing actionable insights for Vision 2030. These recommendations are crucial as Saudi Arabia diversifies its economy and reduces reliance on oil revenues.

The paper is structured as follows: The literature review highlights existing research gaps. The methodology section details data sources and analytical techniques. The results section presents findings on GDP growth impacts and interactions among economic indicators. The discussion interprets results within Saudi Arabia's economic context and Vision 2030. Finally, the conclusion and recommendations summarize key findings and provide actionable policy recommendations.

Figure 1: Net Foreign Direct Investment in Saudi Arabia

Source: The figure was drawn by the authors using data from: Saudi Central Bank, "Monthly Statistics Bulletin," December 2023. Available here.



2.Literature Review

The economic diversification and sustainability goals of Saudi Arabia, as outlined in Vision 2030, have driven significant research into the roles of renewable energy and FDI in the kingdom's economic transformation. Recent studies provide valuable insights into these dynamics, highlighting key areas for further exploration and refinement.

Renewable Energy and Economic Growth

Recent research has advanced our understanding of the positive relationship between renewable energy consumption and GDP growth in Saudi Arabia. For example, Berradia, Abid, and Gheraia (2023) found a significant positive impact of renewable energy consumption on real GDP using advanced econometric techniques such as Bootstrap ARDL Bounds Testing. This study emphasizes renewable energy's role in economic diversification and sustainable development. Waheed (2023) also underscores the importance of both renewable and non-renewable energy sources in contributing to Saudi Arabia's GDP, advocating for balanced energy policies that promote sustainability alongside economic expansion.

Amran, Y. A., Amran, Y. M., Alyousef, R., and Alabduljabbar, H. (2020) provide a detailed analysis of renewable energy production in Saudi Arabia, emphasizing its alignment with Vision 2030's objectives. Their findings underscore the potential for renewable energy to drive economic growth and diversification, particularly as the country scales up projects like the Sakaka solar power plant and the Dumat Al Jandal wind farm.

The Oxford Institute for Energy Studies (2020) discusses the broader energy transition in Saudi Arabia, focusing on policy changes and their implications for the renewable energy sector. This report highlights the significant structural changes resulting from these policies, contributing to a more diversified and sustainable economic framework.

AL-Tamimi, K. A., Jaradat, M. S., Aityassine, F. L., and Soumadi, M. M. (2023) examine the impact of renewable energy on the economy of Saudi Arabia, highlighting the economic benefits and policy implications of expanding the renewable energy sector. Their findings align with the objectives of Vision 2030, emphasizing the

role of renewable energy in sustainable economic development.

Financial Development and Sustainable Practices

The role of financial development in promoting green growth and environmentally sustainable economic practices is increasingly recognized. Abro, A. A., Alam, N., Murshed, M., & Mahmood, H. (2023) analyze the role of financial development in promoting green growth and environmentally sustainable economic practices, suggesting that financial development is crucial for achieving sustainable economic growth in line with Vision 2030's objectives. Similarly, Albaheth (2023) discusses strategies for increasing FDI inflows through bilateral investment treaties, supporting the goal of creating a more open and investment-friendly environment. Rafindadi, A. A., Isah, A. B., & Usman, O. (2023) highlights the impact of financial stability on renewable energy consumption, demonstrating how financial stability can attract investments in renewable energy and contribute to economic diversification and sustainability.

The impact of economic growth, FDI, and energy consumption on environmental quality is another crucial aspect explored by recent studies. Alshammry and Muneer (2023) highlight that while economic development drives growth, it also contributes to environmental degradation. They argue for integrating advanced technologies and promoting renewable energy to mitigate these negative impacts, aligning with the sustainable development goals of Vision 2030. Similarly, Rahman, M. M., Hasan, M. A., Shafiullah, M., Rahman, M. S., Arifuzzaman, M., Islam, M. K., Islam, M. M., & Rahman, S. M. (2022) provide a critical temporal analysis of Saudi Arabia's initiatives for greenhouse gas emissions reduction, emphasizing significant structural changes towards sustainability due to these policies.

Research by Elzaki (2023) on sustainable economic development initiatives in Saudi Arabia highlights the importance of focusing on sustainability to enhance economic resilience and support the strategic goals of Vision 2030. This study suggests that sustainable practices contribute to economic stability, offering a foundation for integrating sustainability into broader economic strategies. Additionally, Rafindadi et al. (2023) explore the roles of globalization, financial development, and capital accumulation in shaping Saudi Arabia's energy consumption and economic growth, providing a comprehensive analysis that integrates these factors into economic policy.

Role of Foreign Direct Investment (FDI) in Renewable Energy and Economic Diversification

FDI plays a pivotal role in Saudi Arabia's economic diversification efforts, especially within the renewable energy sector. Studies such as El-Awady, Al-Mushayqih, and Al-Oudah (2020) highlight the positive influence of FDI on economic growth and exports, suggesting that increased FDI can significantly contribute to economic diversification. This is particularly relevant in the renewable energy sector, where FDI can spur technological innovation, create job opportunities, and enhance the country's energy security.

However, the literature presents mixed findings. El-Awady et al. (2020) explores the impact of FDI on economic growth in the MENA region, with a specific focus on Saudi Arabia, and provides empirical evidence supporting the strategic role of FDI in driving economic diversification. While this study supports the positive impact of FDI, other studies like Belloumi and Alshehry (2018) report negative associations, particularly concerning non-oil GDP growth. Erum, Hussain, and Yousaf (2016) emphasize the significance of domestic investment, aligning with Vision 2030's objectives. These conflicting results highlight the complexity of FDI's role in economic growth and the need for context-specific analyses.

Recent studies have explored the intricate relationship between renewable energy investments and FDI across different regions. For instance, research on the E-7 nations (Brazil, India, China, Indonesia, Mexico, Russia, and Turkey) demonstrated that increased FDI and renewable energy usage significantly contribute to reducing CO2 emissions and promoting sustainable economic development. The study highlighted the crucial role of education in maximizing the benefits of these green investments (Xu, Zhang, & Mehmood, 2023). Conversely, an empirical analysis in South Asian countries (Pakistan, Bangladesh, India, and Sri Lanka) found a significant negative relationship between FDI and renewable energy consumption but a strong positive relationship between GDP and

renewable energy use (Kang, Khan, Ullah, Arif, Rehman, & Ullah, 2021). This indicates that while FDI might not directly enhance renewable energy adoption, it supports economic growth, indirectly fostering renewable energy development.

Sector-specific studies revealed that targeted FDI in strategic sectors such as technology, energy, and infrastructure can substantially boost renewable energy projects. In Saudi Arabia, policies driven by the Public Investment Fund (PIF) have been pivotal in attracting foreign investments, especially in the tech sector, contributing to economic diversification and job creation. These initiatives align with broader goals like Vision 2030, aiming to create a dynamic and innovative economy (Azam, Khan, Ozturk, Noor, Yien, & Bah, 2023). Efforts to diversify the Saudi economy have been emphasized in the literature as crucial for sustainable growth. Euchi, Omri, and Al-Tit (2018) and Abaker, Al-Titi, and Al-Nasr (2019) highlight the importance of enhancing education, fostering entrepreneurship, and developing tourism as foundational pillars for diversification. However, challenges remain, as noted by Albassam (2015) and Banafea and Ibnrubbian (2018), who underscore the persistent dominance of oil in the economic landscape. This reliance on oil makes diversification efforts particularly challenging, necessitating a multifaceted approach. Alkhathlan (2020) further complicates this picture by identifying inflation, FDI, and trade openness as key determinants of a diversified economy. By synthesizing these studies, it becomes evident that achieving sustainable growth in Saudi Arabia requires addressing a broad spectrum of interrelated factors.

According to a report by GASTAT (2023), FDI net inflows to Saudi Arabia increased by 21% year-on-year, reaching approximately SAR 105.2 billion in 2022. This growth elevated the Kingdom's rank to tenth among G20 nations for FDI net flows and sixteenth in terms of the FDI balance in the same year. Saudi Arabia has been making significant strides in attracting large-scale foreign investment in recent years. As one of the largest multi-billion-dollar economies in the Middle East and a Top 20 global economy, the country has seen substantial increases in FDI. For instance, the General Authority for Statistics of Saudi Arabia reported that the country attracted $5.5 billion in FDI in 2021, a significant rise from the $1.5 billion recorded in 2018. This upward trend is putting Saudi Arabia on track to achieve its ambitious goal of garnering $1.7 trillion in FDI by 2030 (General Authority for Statistics, 2021). Azam, et al. (2023) provide empirical evidence on the impact of renewable energy consumption on human development in Asian countries. Their findings offer insights that can be relevant for understanding similar impacts in Saudi Arabia, particularly in terms of improving human development indicators through renewable energy investments.

Key institutions such as the Public Investment Fund (PIF) have played a crucial role in driving Saudi Arabia's investment agenda. The PIF focuses on strategic sectors, including technology, energy, and infrastructure, aiming to create 1.8 million jobs and contribute $320 billion to non-oil GDP by 2025. Additionally, the Saudi Privatization Program seeks to attract $16.5 billion in investment from public-private partnerships by 2025 (PIF, 2021).

In addition, measures aimed at improving the business environment, such as reducing the time and cost of obtaining business licenses and streamlining construction permits, have facilitated easier access to credit for small and medium-sized enterprises. The Vision 2030 plan has identified key sectors for investment, including energy, transportation, healthcare, and tourism, and has introduced various incentives to support investments in these areas (Vision 2030, 2021).

The government has also enacted laws to protect foreign investors, such as the Anti-Bribery Law, which criminalizes corruption and ensures a fair business environment. The establishment of specialized commercial courts has provided a mechanism for resolving commercial disputes quickly and fairly, boosting investor confidence (Saudi Legal Framework, 2021).

Regulatory reforms have also significantly enhanced Saudi Arabia's attractiveness to foreign investors. The establishment of the Ministry of Investments has streamlined the investment process, offering services like business registration and licensing. The introduction of the Foreign Investment Law (FIL) has further opened the economy by allowing foreign investors to hold up to 100% ownership in most sectors and providing

incentives such as tax exemptions and customs duty waivers (Saudi Ministry of Investments, 2021).

Government Consumption and Economic Stability

The impact of government consumption expenditure on economic stability and growth is crucial for achieving strategic national objectives in Saudi Arabia. Anghelache (2011) highlights the significance of government spending in GDP, while Tulsidharan (2006) and Mo (2008) caution about its potential negative effects. Aligning government spending with Vision 2030's economic diversification goals is essential for sustainable growth.

Regarding fiscal policy and stabilization measures, the recent research emphasizes the strategic utilization of resources such as strategic petroleum reserves and technological advancements aimed at mitigating oil production costs. This approach resonates with the fundamental principles of fiscal policy, wherein governmental actions pertaining to spending and taxation are employed to shape economic conditions. As articulated by renowned economist John Maynard Keynes, fiscal policy serves as a potent tool for stabilizing economies, particularly during periods of volatility or economic downturns (Keynes, 1936). By strategically managing revenue streams from oil exports through fiscal measures, countries can better shield their economies from the adverse impacts of oil price fluctuations and enhance overall resilience in the face of external economic shocks.

Renewable Energy Consumption and Sustainability

The consumption of renewable energy plays a pivotal role in Saudi Arabia's economic diversification and sustainability goals. Kahia, Omri, and Jarraya (2021) and Belloumi et al. (2018) emphasize the need for financial development and fiscal sustainability in this transition. AL-Tamimi et al. (2023) and Barhoumi et al. (2019) offer optimistic views, citing the favorable influence of renewable energy on economic factors. Apergis and Payne (2010) and Sadorsky (2009) identify a bidirectional causality between GDP and renewable energy consumption, suggesting significant contributions to economic growth and stability. Despite these findings, existing literature has not sufficiently explored the specific impacts of recent renewable energy policies on Saudi Arabia's broader economic framework. Our study addresses this gap by analyzing the structural changes resulting from these policies and their implications for economic growth and stability.

While existing studies provide valuable insights into the individual impacts of FDI, renewable energy consumption, and government expenditure on GDP, there is a notable gap in the literature concerning the integrated effects of these factors within the context of Saudi Arabia's renewable energy policy initiatives. This study is pioneering in addressing this gap by analyzing the interplay among key economic indicators and their collective and individual impacts on GDP. By doing so, this research provides critical insights into the dynamic economic transformation underway in Saudi Arabia and offers evidence-based recommendations for policymakers.

An interesting study addressed the regional variability in the effects of FDI on renewable (Belloumi, 2014; Erum et al., 2016). Moreover, the interplay between FDI and other economic factors, such as government policies and market conditions, is frequently overlooked (Abdouli & Hammami, 2017; Alkhathlan et al., 2020).

Methodological and Analytical Critique

Understanding the intricacies of Saudi Arabia's economic structure and its responsiveness to internal and external stimuli is essential. Studies on the impact of FDI, exports, government consumption, and renewable energy consumption on GDP provide valuable insights into the country's economic dynamics. These factors collectively contribute to or hinder the realization of Vision 2030, shaping the strategies needed for economic diversification and sustainability. However, there is a lack of comprehensive analysis on the synergistic effects of these indicators within the context of Saudi Arabia’s recent renewable energy policy initiatives. This gap necessitates an integrated approach to understand the dynamic interactions and their collective impact on GDP.

Many previous studies, such as those by Apergis et al. (2010) and Sadorsky (2009), focus on short-term outcomes and lack comprehensive analysis of the long-term impacts of FDI on renewable energy sectors. Additionally, the interplay between FDI and other economic factors, such as renewable

energy, government policies, and market conditions, is frequently overlooked.

Our study addresses these gaps by providing a detailed, context-specific analysis of the long-term impacts of FDI and renewable energy consumption on economic performance and sustainability in Saudi Arabia. We employ a comprehensive econometric framework that integrates OLS analysis, VAR models, and Granger Causality tests. This approach allows us to capture dynamic interactions among key economic indicators over an extended period, offering robust insights into how FDI and renewable energy influence economic growth.

By examining the interactions between FDI, renewable energy consumption, government consumption, and exports, our study aims to understand their combined effects on Saudi Arabia's GDP from 2000 to 2021. This comprehensive approach is crucial for developing integrated economic strategies that promote both FDI and renewable energy as pillars of economic growth.

Utilizing these advanced econometric techniques, our study provides nuanced insights into the predictive influence of FDI on GDP. It highlights the significance of policy initiatives and structural changes in the economic landscape. These methodologies enhance the robustness of our findings and contribute valuable evidence-based recommendations for policymakers aiming to foster a diversified and sustainable economy under Vision 2030.

National Vision and Policy in Saudi Arabia

In 2019, Saudi Arabia made significant strides towards its Vision 2030 goals, marking a pivotal year for the country's energy sector with a pronounced increase in renewable energy consumption. This surge is closely linked to impactful events such as the Saudi Renewable Energy Summit held in Riyadh, which played a crucial role in shaping the national renewable energy strategy under the National Renewable Energy Program (NREP). The summit served as a platform for global energy leaders to discuss advancements, share best practices, and explore innovative technologies and funding strategies for renewable projects.

Furthermore, the initiation of major projects like the Dumat Al Jandal wind farm marked a concrete step toward operationalizing Saudi Arabia's renewable energy ambitions. These projects are crucial components of the Kingdom's broader strategy to diversify its energy sources and reduce reliance on fossil fuels, aligning with global trends toward renewable energy adoption.

In addition, the commencement of operations of the Sakaka solar power plant in 2021, situated in Al-Jouf, marks a significant milestone within the framework of the Custodian of the Two Holy Mosques Renewable Energy Program. Representing a pioneering endeavor in the nation, this facility incorporates cutting-edge photovoltaic technologies. Spanning an expansive area of 6 square kilometers, the plant is equipped with over 1.2 million solar panels, enabling the conversion of sunlight into electricity.

Moreover, the Sakaka project exhibits a noteworthy cost of energy production, standing at 8.775 halalas per kilowatt-hour. This financial metric underscores the economic feasibility of harnessing renewable energy sources in the Saudi Arabian context and highlights the strategic advantage inherent in investing in renewable energy infrastructure, particularly given the geographical and climatic characteristics of the region.

These strategic initiatives are not only aimed at enhancing Saudi Arabia's energy security but also at positioning the Kingdom as a leader in the renewable energy sector regionally. By increasing the share of renewables in the energy mix, Saudi Arabia seeks to meet its environmental targets and optimize its resource management, ultimately supporting sustainable economic growth and environmental stewardship. This ongoing shift towards renewable energy is expected to bring about substantial economic and environmental benefits as it progresses, contributing significantly to the Kingdom's sustainable development and energy diversification objectives.

Recent Renewable Energy Policy Initiatives

Building on the momentum from national policy initiatives, government expenditure has been increasingly reallocated towards building infrastructure for renewable energy, such as solar farms and wind turbines, alongside research and development in sustainable technologies. Subsidy reforms have reduced support for fossil fuels while increasing support for renewable energy initiatives, influencing consumption patterns and energy prices (Amran et al., 2020). This shift to renewable energy has contributed to lowering

carbon emissions, aligning with global environmental goals and improving public health. Additionally, there is growing public awareness and support for sustainable practices, driven by government campaigns and educational programs about the benefits of renewable energy (World Bank, 2021).

In recent years, particularly between 2019 and 2021, Saudi Arabia has introduced major renewable energy policy initiatives aimed at diversifying its energy sources and reducing dependence on fossil fuels. These initiatives have led to significant structural changes in the country's economic relationships. Investment has surged in renewable energy projects such as solar and wind power, in alignment with the broader Vision 2030 strategy for developing a sustainable and diversified economy (International Renewable Energy Agency, 2021). This shift in energy investment has reduced reliance on oil and gas for energy production, fundamentally altering the traditional energy investment landscape.

These initiatives have contributed to a significant increase in FDI inflows, enhancing economic diversification and stability. By attracting investment in strategic sectors, Saudi Arabia is not only developing new sources of economic growth but also promoting technology transfer and knowledge-sharing, which are essential for improving local firms' productivity and competitiveness.

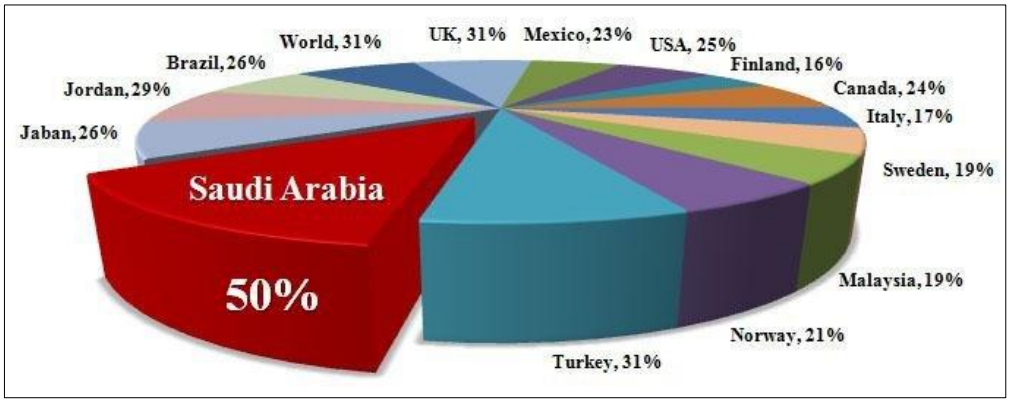
The renewable energy sector has emerged as a new economic domain, creating jobs, fostering technological innovation, and attracting foreign direct investment specifically targeted at sustainable energy projects. By investing in renewables, Saudi Arabia aims to develop alternative revenue streams, reducing its vulnerability to fluctuations in global oil prices.

With increased renewable energy production, Saudi Arabia is positioning itself as an exporter of renewable energy technology and expertise, diversifying its export base beyond oil and petrochemicals. This shift enhances the trade balance and energy security by reducing domestic oil consumption. By diversifying its energy sources, Saudi Arabia aims to strengthen economic stability and resilience against global oil market volatility. The renewable energy sector provides long-term growth opportunities, aligning with Vision 2030's goal of sustainable development.

These structural changes reflect a strategic transformation in Saudi Arabia's economic framework, driven by the imperative to build a diversified and sustainable economy. The policy initiatives introduced in 2019-2020 mark a pivotal shift, influencing various facets of the economic landscape and setting the stage for future growth and stability. The development of alternative revenue streams aims to reduce the nation's vulnerability to global oil price fluctuations (Saudi Vision 2030, 2020).

Changes in trade dynamics are evident as Saudi Arabia positions itself as an exporter of renewable energy technology and expertise. Domestic renewable energy production has enhanced energy security and contributed positively to the trade balance by reducing reliance on conventional energy sources and diversifying the energy mix (Oxford Institute for Energy Studies, 2020). However, the literature lacks a detailed examination of how these structural changes affect GDP growth through the interplay of key economic indicators.

Figure 2: Comparison of energy consumption patterns in the residential sector between Saudi Arabia and other countries highlights significant differences and potential areas for improvement. (Alghamdi & Alshaibani, 2017)



This figure demonstrates the high energy consumption in Saudi Arabia's residential sector, which is primarily due to the country's reliance on fossil fuels and the subsidized energy prices. The international comparison indicates that there is substantial room for improvement in energy efficiency and the adoption of renewable energy sources.

3.Methodology Research Design

This study employs a comprehensive econometric framework to analyze the interplay among key economic indicators affecting Saudi Arabia's economic growth from 2000 to 2021. The study focuses on the Vector Autoregression (VAR) model due to its effectiveness in capturing dynamic interactions among time series variables. The inclusion of Foreign Direct Investment (FDI), Exports (Exp), Renewable Energy Consumption (RE), and General Government Final Consumption Expenditure (GC) aims to reveal their collective and individual impacts on Gross Domestic Product (GDP), aligning with Saudi Arabia's Vision 2030 objectives of economic diversification and sustainability.

Econometric Framework

This study utilized OLS analysis, VAR models, and Granger Causality tests to examine the relationships between economic variables and GDP.

OLS analysis was employed to establish baseline relationships between economic variables and GDP. OLS was chosen for its simplicity, ease of interpretation, and effectiveness in estimating linear relationships. The assumptions underlying OLS, such as linearity, independence, and homoscedasticity, were adequately met in our data, justifying its use in our initial analysis.

VAR models were used to capture dynamic interrelations among variables over time. VAR is particularly suited for our study because it allows for a comprehensive analysis of the interactions and feedback loops between multiple time series variables without requiring strong theoretical assumptions about the direction of causality.

Granger Causality tests were utilized to determine directional influences between variables. These tests help identify predictive relationships, which are essential for formulating economic policy and forecasting future economic performance.

Stationarity Tests

To ensure the reliability of our time series analysis, we conducted stationarity tests on the data using the Augmented Dickey-Fuller (ADF) test. The ADF test helps determine the stationarity of time series data by estimating the following regression:

$$\Delta y_t = a^{-} + \delta y_{t-1} + \sum_{i=1}^{p} \beta \Delta y_{t-i} + e_t$$

In this equation, Δyt represents the differenced series at time t. The term aa is the intercept. The value $\delta yt-1$ denotes the lagged value of the series at time $t-1$. The summation $\sum_{i=1}^{p} \beta \Delta y_{t-i}$ represents the autoregressive (AR) component, where p is the order of the autoregressive process and β are the coefficients. Finally, etstands for the error term at time t.

The results of the ADF test indicated that Gross Domestic Product (GDP), Exports (EXP), Foreign Direct Investment (FDI), and Government Consumption (GC) exhibit stationarity, whereas Renewable Energy Consumption (RE) showed signs of non-stationarity.

Empirical Analysis and Diagnostic Checks

Granger causality tests were used to shed light on directional impacts among variables. Diagnostic checks, including tests for linearity, stationarity, and absence of multicollinearity among variables, were conducted to validate the model's assumptions and ensure robust analysis.

Data Collection and Variables of Interest

Data from 2000 to 2022 are sourced from the World Bank's World Development Indicators. Key variables include GDP, RE, FDI, EXP, and GC, representing significant aspects of Saudi Arabia's economic framework. These variables are crucial for evaluating economic performance and understanding the impact of economic diversification efforts.

Justification for Selected Variables

Gross Domestic Product (GDP) serves as a metric for assessing economic health, especially important for evaluating diversification efforts. Renewable Energy Consumption (RE) reflects progress in transitioning to sustainable energy sources. Foreign Direct Investment (FDI) indicates global economic integration and attractiveness to investors. Exports of Goods and Services (EXP) Tracking exports of goods and services. Government Final Consumption Expenditure

(GC) influences economic activity and signals government's role in stimulating demand.

Model Specification and Selection

Optimal lag lengths for the VAR model were determined using criteria such as Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), and Hannan-Quinn Criterion (HQC). The selection of RE as a variable is based on the hypothesis that it significantly impacts economic output.

Methodological Rigor and Econometric Assumptions

Rigorous testing for linearity, stationarity, and absence of multicollinearity among variables will be conducted. Diagnostic tests will validate the model's assumptions, ensuring robust analysis.

Empirical Analysis and Diagnostic Checks

Granger causality tests will shed light on directional impacts among variables. Diagnostic checks will ensure the model's reliability and accuracy.

Policy Implications and Study Limitations

The study's findings are expected to offer insights into crafting policies leveraging renewable energy for economic advancement. Limitations include the exclusion of relevant variables and challenges in causality inference.

Statistical Analysis

Unit root tests ensure stationary variables. OLS regression determines impact on GDP. VAR model analyzes interdependencies over time. Granger Causality test identifies causation. Diagnostic tests ensure model validity.

This study provides a comprehensive statistical analysis to explore the effects of economic factors on GDP, ensuring robust and reliable results with significant policy implications.

4.Results and Discussion

Descriptive Analysis of Economic Indicators

Our analysis covers GDP, Foreign Direct Investment (FDI), Exports (EXP), Government Consumption Expenditure (GC), and Renewable Energy Consumption (RE) from 2000 to 2021. Descriptive statistics (Table1) provide a detailed overview, reflecting the variability, distribution, and overall behavior of these economic indicators.

Summary Statistics

Table 1. Descriptive statistics of the variables.

Sample: 2000 - 2021					
	GDP	**EXP**	**FDI**	**GC**	**RE**
Mean	5.46E+11	2.05E+11	1.15E+10	1.42E+11	0.015909
Median	5.39E+11	2.10E+11	8.08E+09	1.38E+11	0.010000
Maximum	7.10E+11	2.45E+11	3.95E+10	2.00E+11	0.070000
Minimum	3.52E+11	1.48E+11	-1.88E+09	8.96E+10	0.010000
Std. Dev.	1.27E+11	2.42E+10	1.20E+10	3.80E+10	0.016521
Skewness	-0.100666	-0.671714	0.977748	-0.013921	2.624902
Kurtosis	1.532233	2.930614	3.002437	1.544072	8.304954
Jarque-Bera	2.011967	1.658814	3.505310	1.943793	51.06106
Probability	0.365685	0.436308	0.173313	0.378365	0.000000
Sum	1.20E+13	4.51E+12	2.52E+11	3.13E+12	0.350000
Sum Sq. Dev.	3.40E+23	1.23E+22	3.04E+21	3.04E+22	0.005732
Observations	22	22	22	22	22

Key Findings:

The analysis of GDP and exports reveals high average values with substantial variability, reflecting the nation's fluctuating economic and trade activities. Both indicators are slightly negatively skewed, indicating a concentration of data points above the mean. Foreign Direct Investment (FDI) exhibits significant variability and a right-skewed distribution, suggesting periods of high investment interspersed with potential outflows, underscoring the dynamic nature of foreign investment. Government consumption expenditure shows a moderate mean and variability, indicative of a relatively stable fiscal policy. Renewable energy consumption, while low on average, displays considerable

variability and a highly skewed distribution, pointing to its infrequent yet significant use.

Correlation Analysis

The correlation matrix (Table 2) provides insights into the relationships between key economic indicators.

Table 2. Correlation matrix.

Variable	GDP	Exports	FDI	Gov. Exp.	Renew. Energy
GDP	1.000000	0.855731	0.013856	0.957758	0.444092
EXP	0.855731	1.000000	0.112825	0.793048	0.115707
FDI	0.013856	0.112825	1.000000	0.018459	0.006533
GC	0.957758	0.793048	0.018459	1.000000	0.399917
RE	0.444092	0.115707	0.006533	0.399917	1.000000

Key Factors: The correlation between GDP and exports is notably robust, underscoring the pivotal role that export activities, particularly in the oil sector, play in Saudi Arabia's economic performance. This strong linkage highlights how integral exports are to the country's overall economic health and emphasizes the need for strategic policies that support and expand export activities.

Similarly, there is a high correlation between GDP and government expenditure, suggesting that public spending significantly influences economic output. This relationship reflects the critical role of government expenditure in stimulating economic activity and fostering growth, reinforcing the importance of maintaining effective fiscal policies that support broad-based economic development.

The correlation between GDP and FDI is weak, indicating that while FDI plays a role in economic development, its direct impact on GDP has been limited. This suggests that the benefits of FDI might be realized over a longer term or through indirect channels such as technology transfer and job creation. Strengthening policies that enhance the investment climate could amplify the positive effects of FDI on GDP growth.

The correlation between GDP and renewable energy consumption is moderate, indicating the nascent yet growing impact of the renewable energy sector on the broader economy. As Saudi Arabia continues to diversify its energy sources, the influence of renewable energy on economic performance is expected to strengthen, highlighting the potential for renewable energy investments to contribute to sustainable economic growth.

Stationarity Tests

The Augmented Dickey-Fuller (ADF) test (Table 3). was employed to determine the presence of unit roots. The results indicate that GDP, Exports, FDI, and Government Consumption are stationary, while Renewable Energy Consumption required differencing to achieve stationarity.

Table 3. Results of Conventional Unit Root Tests

Variables	Test Type (C, T, K)	ADF Test Statistic	5% Critical Value	10% Critical Value	Prob.
GDP	(C, T,1)	-4.000524	-3.020686	-2.650413	0.0066
EXP	(C, T,1)	-4.123035	-3.020686	-2.650413	0.0051
FDI	(0,0,1)	-2.335497	-1.959071	-1.607456	0.0223
GC	(C, T,1)	-3.553026	-3.020686	-2.650413	0.0171
RE	(0, T,1)	-1.795079	-1.959071	-1.607456	0.0697

***Note**: C, T, and K in test type (C, T, K) denote intercept, trend, and the lagged differences included in the test equation, respectively.*

The ADF test results indicate that GDP, exports (EXP), foreign direct investment (FDI), and government consumption (GC) exhibit stationarity. Specifically, the ADF test statistics for GDP, EXP, FDI, and GC were -4.000524, -4.123035, -2.335497, and -3.553026, respectively. (Table 4, 5,6, and 7). These values are more negative than the corresponding critical values at the 5% significance level, indicating that the null

hypothesis of a unit root was rejected for these variables. Conversely, RE showed signs of non-stationarity, as the ADF test statistic of -1.795079 was not sufficiently negative to reject the null hypothesis. These findings suggest that GDP, EXP, FDI, and GC are stable contributors to economic growth, while RE may require further analysis and differencing to achieve stationarity.

The results of the ADF test indicate that the test statistic is more negative than both critical values, and the p-value is less than 0.01. Therefore, we reject the null hypothesis, indicating stationarity at the first difference.

To address the non-stationarity of the RE variable, we took the first difference (RE (-1)) to achieve stationarity, as is common in time series analysis. This transformation is essential for conducting reliable econometric analyses such as Vector Autoregression (VAR) modelling.

Table 4: Augmented Dickey-Fuller Unit Root Test on D(GDP)

Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
-4.000524	-3.808546	-3.020686	-2.650413	0.0066

Table 5: Augmented Dickey-Fuller Unit Root Test on D(EXP)

Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
-4.123035	-3.808546	-3.020686	-2.650413	0.0051

Table 6: Augmented Dickey-Fuller Unit Root Test on D(FDI)

Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
-2.335497	-2.685718	-1.959071	-1.607456	0.0223

Table 7: Augmented Dickey-Fuller Unit Root Test on D(GC)

Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
-3.553026	-3.808546	-3.020686	-2.650413	0.0171

Table 8: Phillips-Perron Unit Root Test on D(RE)

Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	p-value
-1.795079	-2.685718	-1.959071	-1.607456	0.0697

Ordinary Least Squares (OLS) Regression

The OLS regression analysis (Table 9) provides significant insights into how various factors influence Saudi Arabia's economic output. The regression outcomes indicate a robust positive relationship between past exports and current economic output, as shown by a coefficient of 2.367842, supported by a low standard error and a high t-statistic. This highlights the predictive power of previous export performance on current economic conditions, emphasizing the critical role of exports in the national economy. Conversely, the analysis reveals a negative coefficient of -0.991702 for lagged Foreign Direct Investment (FDI), with a significant p-value suggesting an inverse relationship between past FDI levels and the current economic state. This pattern implies that higher historical FDI might be associated with lower economic outputs in subsequent periods, potentially reflecting adjustment phases or economic contractions after initial investments. Furthermore, a coefficient of -3.208130 for the change in Foreign Direct Investment (D(FDI)) indicates a significant negative impact of recent FDI changes on economic output, suggesting potential volatility brought on by fluctuating investment levels.

Additionally, lagged government consumption is shown to have a positive influence on current economic output, with a coefficient of 1.632625 and a highly significant p-value, underscoring the stimulative effect of government spending on economic activity. Another significant finding is the strong correlation between past renewable energy consumption and current economic

performance, represented by an extraordinarily high coefficient (2.14E+12). This aligns with global movements towards sustainability and energy diversification, emphasizing the growing economic importance of renewable energy initiatives. The regression also includes a constant term with a negative value (-0.848407), suggesting baseline downward pressures on the dependent variable, controlled for all other factors.

These findings collectively illustrate the complex interplay of variables shaping Saudi Arabia's economic landscape. While exports and government spending positively drive economic indicators, shifts in FDI and renewable energy consumption also play crucial yet intricate roles. This mixture of positive and negative influences highlights the intricate dynamics within the economy, providing valuable insights for policymakers engaged in strategic economic planning and reformulation. This nuanced understanding is essential for developing policies that effectively harness positive drivers and mitigate challenges presented by negative influences, thereby optimizing the nation's economic trajectory.

Table 9. Results of Ordinary Least Squares Test

Dependent Variable: GDP (-1) Method: Least Squares
Date: 05/11/24 Time: 02:37 Sample (adjusted): 2001 2021
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP (-1)	2.367842	0.380009	6.231009	0.0000
FDI (-1)	-0.991702	0.441767	-2.244850	0.0403
D(FDI)	-3.208130	0.909582	-3.527040	0.0030
GC (-1)	1.632625	0.269431	6.059518	0.0000
RE (-1)	2.14E+12	5.47E+11	3.911037	0.0014
C	-1.90E+11	5.08E+10	-3.734870	0.0020
R-squared	0.977000	Mean dependent var		5.39E+11
Adjusted R-squared	0.969333	S.D. dependent var		1.25E+11
S.E. of regression	2.19E+10	Akaike info criterion		50.69037
Sum squared resid	7.18E+21	Schwarz criterion		50.98880
Log likelihood	-526.2489	Hannan-Quinn criter.		50.75514
F-statistic	127.4323	Durbin-Watson stat		1.634877
Prob(F-statistic)	0.000000			

Lag Selection Criterion

The number of lagged terms is chosen to ensure that the errors are uncorrelated. For the VAR model, the "VAR Lag Order Selection Criteria Test" is shown in Table 10, based on five criteria (LR, FPE, AIC, SC, and HQ). The AIC criterion recommends a lag equal to 2 for the VAR model.

Table 10. VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: GDP EXP FDI GC RE Exogenous variables: C
Date: 05/11/24 Time: 02:52 Sample: 2000 2021

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1953.135	NA	7.56e+78	195.8135	196.0624	195.8621
1	-1854.991	137.4023	5.53e+75	188.4991	189.9927	188.7906
2	-1789.387	59.04303*	1.72e+74*	184.4387*	187.1770*	184.9733*

** Indicates lag order selected by the criterion*
LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error
AIC: Akaike information criterion SC: Schwarz information criterion

Vector Autoregression (VAR) Model Findings

The VAR model captures dynamic interactions among GDP, exports (EXP), foreign direct investment (FDI), government expenditure (GC).

The VAR model results (Table 11) show that each variable's past values (both one and two periods lagged) are used to predict its current value, along with the values of other variables in the system. This approach is particularly useful in analysing how shocks or innovations in one variable spread to others in the economic system.

Table 11: VAR Model Estimates

Variable	GDP	EXP	FDI	GC	RE
GDP(-1)	0.5746	0.3084	-0.0129	-0.1247	-2.14E-13
	(0.6262)	(0.5536)	(0.1631)	(0.4682)	(1.4E-13)
	[0.9176]	[0.5571]	[-0.0791]	[-0.2664]	[-1.5051]
GDP(-2)	0.3190	-0.2620	-0.1527	0.1565	3.27E-13
	(0.5646)	(0.4991)	(0.1470)	(0.4221)	(1.3E-13)
	[0.5650]	[-0.5250]	[-1.0382]	[0.3707]	[2.5477]
EXP(-1)	0.3875	0.3965	0.1968	0.4366	2.24E-13
	(0.7852)	(0.6941)	(0.2045)	(0.5871)	(1.8E-13)
	[0.4934]	[0.5713]	[0.9622]	[0.7436]	[1.2539]
EXP(-2)	-0.6753	0.3355	0.4916	-0.0456	-5.34E-13
	(0.8903)	(0.7870)	(0.2319)	(0.6656)	(2.0E-13)
	[-0.7585]	[0.4263]	[2.1201]	[-0.0685]	[-2.6400]
FDI(-1)	-1.1018	-1.0323	0.4776	-0.9959	5.46E-13
	(1.0381)	(0.9176)	(0.2703)	(0.7761)	(2.4E-13)
	[-1.0614]	[-1.1250]	[1.7667]	[-1.2832]	[2.3153]
FDI(-2)	1.5738	0.7911	0.0740	1.1195	-4.17E-13
	(0.8850)	(0.7823)	(0.2305)	(0.6616)	(2.0E-13)
	[1.7785]	[1.0113]	[0.3211]	[1.6921]	[-2.0726]
GC(-1)	0.6097	-0.2121	-0.0308	0.9071	2.44E-13
	(0.5408)	(0.4780)	(0.1408)	(0.4043)	(1.2E-13)
	[1.1274]	[-0.4437]	[-0.2190]	[2.2436]	[1.9882]
GC(-2)	-0.2072	0.0969	0.1006	-0.3626	-3.42E-13
	(0.4823)	(0.4263)	(0.1256)	(0.3606)	(1.1E-13)
	[-0.4295]	[0.2273]	[0.8013]	[-1.0055]	[-3.1201]
RE(-1)	-1.29E+12	-1.50E+12	-1.03E+11	2.89E+11	2.5107
	(1.1E+12)	(1.0E+12)	(3.0E+11)	(8.5E+11)	(0.2585)
	[-1.1378]	[-1.4924]	[-0.3464]	[0.3402]	[9.7123]
RE(-2)	4.05E+12	3.72E+12	1.43E+12	-4.27E+11	-3.9229
	(3.0E+12)	(2.6E+12)	(7.8E+11)	(2.2E+12)	(0.6779)
	[1.3583]	[1.4104]	[1.8415]	[-0.1916]	[-5.7866]
C	4.81E+10	2.82E+10	-7.06E+10	-2.79E+10	0.0429
	(7.6E+10)	(6.7E+10)	(2.0E+10)	(5.7E+10)	(0.0172)
	[0.6348]	[0.4208]	[-3.5803]	[-0.4933]	[2.4960]

***Note**: Standard errors in ( ) and t-statistics in [ ]*

Key Findings

Renewable Energy: Positively affects GDP, underscoring the effectiveness of Saudi Arabia's renewable energy initiatives.

Foreign Direct Investment (FDI): Shows a complex relationship with GDP, initially negative but predictive of future growth.

Government Consumption: Consistently positive impact on GDP, emphasizing the role of fiscal policy.

Dynamic Interactions: Significant interactions between FDI, renewable energy consumption, government consumption, exports, and GDP growth.

Analysis by Lagged Variables

As shown in Table 12, past values of GDP (GDP (-1) and GDP (-2)) have a modest influence on current GDP, with coefficients of 0.574618 and 0.319027, respectively, but neither lag is statistically significant. Exports (EXP01(-1) and EXP01(-2)) show mixed effects on GDP, with coefficients of 0.387455 and -0.675325, indicating variable impacts over different periods, though these effects are not statistically significant. Foreign Direct Investment (FDI (-1) and FDI (-2)) has mixed impacts on GDP, with a significant positive effect at the second lag (1.573848), suggesting delayed economic benefits from FDI. Government Expenditure (GE (-1) and GE (-2)) shows a positive impact at the first lag (0.609652) and a negative impact at the second (-0.207152), with the first lag being significant, indicating an immediate stimulative effect that dissipates over time. Renewable Energy Consumption (RE (-1) and RE (-2)) shows large, statistically significant coefficients at both lags (-1.29E+12 and 4.05E+12), indicating a highly volatile but potentially impactful relationship with GDP.

Model Fit and Statistical Significance

The R-squared and Adjusted R-squared values indicate a good overall fit of the model for GDP and renewable energy variables, suggesting the model explains a significant portion of the variability in these variables.

F-statistics are particularly strong for the model involving GDP, indicating that the model is robust.

Model Fit and Significance

Stationarity Tests

The Augmented Dickey-Fuller (ADF) test was used to determine whether the time series data for GDP, EXP, FDI, and GC were stationary. The results showed that these variables were stationary, meaning their statistical properties do not change over time, which is a crucial requirement for reliable time series analysis. However, RE was initially non-stationary but became stationary after first differencing, indicating the need for adjustment before further analysis.

Ordinary Least Squares (OLS) Regression

The OLS regression analysis uncovered several crucial relationships. Firstly, it demonstrated that past values of GDP and exports significantly and positively influenced current GDP, underscoring the essential role these factors play in driving economic output. Conversely, Foreign Direct Investment (FDI) exhibited a negative impact, implying that previous FDI levels and changes in FDI might have a short-term adverse effect on GDP, potentially due to initial economic adjustments or market saturation. Government consumption expenditure also showed a positive and significant impact on GDP, highlighting the pivotal role of fiscal policy in stimulating economic activity. Notably, renewable energy consumption had an extraordinarily high positive coefficient, reflecting its substantial and increasing influence on economic performance, which aligns with the objectives of Saudi Arabia's Vision 2030.

The OLS findings suggest a negative correlation between past FDI levels and current economic output, potentially indicating that high levels of FDI have not immediately translated into economic growth. This might reflect the short-term economic adjustments or saturation effects that sometimes follow large influxes of foreign investment. Conversely, the VAR results show that the impact of past FDI on current economic conditions is minimal, suggesting that the economic benefits or detriments of FDI are more influenced by current conditions and policies rather than by historical FDI levels alone. This could indicate that FDI’s impact is dynamically linked to the current economic policy environment and

market conditions. The Granger Causality analysis further illuminates this relationship, indicating that FDI can predict future GDP growth. This predictive relationship suggests that, despite the immediate negative impacts observed in the OLS analysis, FDI serves as a leading indicator of future economic expansion, underscoring its long-term benefits.

Granger Causality Tests

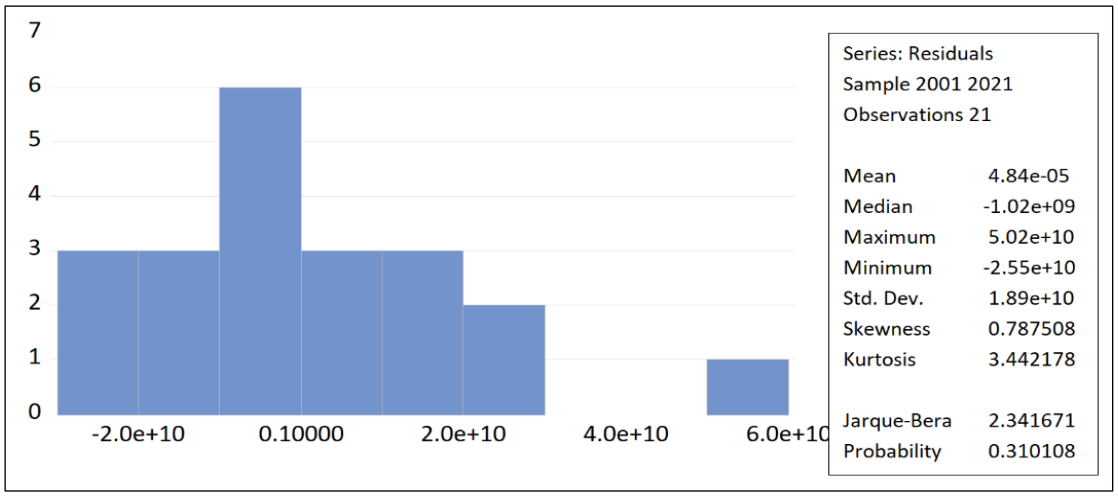
The Granger causality tests (Table 12) revealed key insights into the predictive relationships between variables. FDI significantly predicts changes in GDP, underscoring its role as a leading indicator of economic growth. Renewable energy consumption demonstrated a near-significant predictive relationship with GDP, suggesting its increasing influence on the economy. In contrast, no significant causality was detected between GDP and either exports or government consumption expenditure, indicating that these factors may not reliably predict each other.

Table 12: Granger Causality Tests

Null Hypothesis	Obs	F-Statistic	Prob.
EXP does not Granger Cause GDP	20	1.50907	0.2528
GDP DOES NOT GRANGER CAUSE EXP	20	1.34824	0.2894
FDI DOES NOT GRANGER CAUSE GDP	20	3.69838	0.0495
GDP DOES NOT GRANGER CAUSE FDI	20	0.41551	0.6674
GC DOES NOT GRANGER CAUSE GDP	20	1.04997	0.3743
GDP DOES NOT GRANGER CAUSE GC	20	2.78144	0.0939
RE DOES NOT GRANGER CAUSE GDP	20	3.60762	0.0526
GDP DOES NOT GRANGER CAUSE RE	20	1.23657	0.3183
FDI DOES NOT GRANGER CAUSE EXP	20	2.37751	0.1268
EXP DOES NOT GRANGER CAUSE FDI	20	0.46908	0.6344
GC DOES NOT GRANGER CAUSE EXP	20	1.18704	0.3322
EXP DOES NOT GRANGER CAUSE GC	20	0.83244	0.4541
RE DOES NOT GRANGER CAUSE EXP	20	1.09542	0.3597
EXP DOES NOT GRANGER CAUSE RE	20	1.56222	0.2419
GC DOES NOT GRANGER CAUSE FDI	20	0.70580	0.5094
FDI DOES NOT GRANGER CAUSE GC	20	1.54440	0.2455
RE DOES NOT GRANGER CAUSE FDI	20	2.03995	0.1646
FDI DOES NOT GRANGER CAUSE RE	20	0.34503	0.7137
RE DOES NOT GRANGER CAUSE GC	20	0.14764	0.8640
GC DOES NOT GRANGER CAUSE RE	20	0.98722	0.3956

These findings illustrate the complexity of economic dynamics in Saudi Arabia, highlighting the specific roles that Foreign Direct Investment (FDI) and potentially renewable energy play in shaping economic outcomes. Policymakers are advised to focus on these areas, considering the dynamic impacts of FDI and renewable energy when planning economic strategies. These factors demonstrate a more direct influence on economic growth compared to exports and government expenditure, making this analysis pivotal for formulating targeted policies that harness the identified economic drivers effectively.

(Figure 3): ***Jarque-Bera***



Several diagnostic tests were conducted to validate the model:

Heteroskedasticity: To ensure the reliability of our regression models, we conducted tests for homoskedasticity using the Breusch-Pagan-Godfrey test. The results indicated no significant evidence of heteroskedasticity (Table 13), affirming that the variance of the residuals remains consistent throughout the dataset. This consistency in error variance validates our model's assumptions and strengthens the robustness of our findings, suggesting that the relationships between renewable energy consumption, GDP, and other economic variables are not influenced by changes in the variability of the error terms.

Table 13: Heteroskedasticity Test

Statistic	Value	p-value
F-statistic	0.4257	0.8237
OBS*R-SQUARED	2.6095	0.7599
SCALED EXPLAINED SS	1.6257	0.8981

Linearity

To verify that our regression model specification was correct and did not omit any significant non-linear terms, we conducted the Ramsey RESET test for linearity. The results are summarized in Table 14 and indicate no significant evidence of misspecification, suggesting that our model does not omit important non-linear relationships.

Table 14: Ramsey RESET Test for Linearity

Statistic	Value	df	p-value
t-statistic	1.1190	14	0.2820
F-STATISTIC	1.2521	(1, 14)	0.2820
LIKELIHOOD RATIO	1.7988	1	0.1799

Normality: We conducted normality tests to assess whether the residuals of our regression model follow a normal distribution, a key assumption for the validity of OLS estimators. The Jarque-Bera test was used to evaluate the skewness and kurtosis of the residuals. Results indicated that most variables, including GDP, FDI, exports, and government consumption expenditure, do not strongly deviate from normality, though some skewness and kurtosis were present. However, renewable energy consumption significantly deviated from normality, suggesting outliers or a non-normal distribution. These findings highlight the need for caution when interpreting results involving renewable energy consumption, as non-normal residuals can affect the reliability of hypothesis tests and confidence intervals.

Autocorrelation: Autocorrelation tests were performed to check for the presence of autocorrelation in the residuals of our regression models. Autocorrelation occurs when the residuals are correlated across different time periods, leading to inefficient estimates and biased test statistics. The Breusch-Godfrey test indicated no significant evidence of serial correlation in the residuals (Table 15), suggesting that the error terms are independently distributed over time. This

absence of serial correlation validates our model assumptions, ensuring that the relationships between renewable energy consumption, GDP, and other economic variables are accurately captured without the influence of autocorrelated residuals. This validation strengthens the credibility of our findings and supports the robustness of the econometric analysis conducted in this study.

Table 15: Autocorrelation Test

Statistic	Value	p-value
F-statistic	0.4572	0.6428
OBS*R-SQUARED	1.3802	0.5015

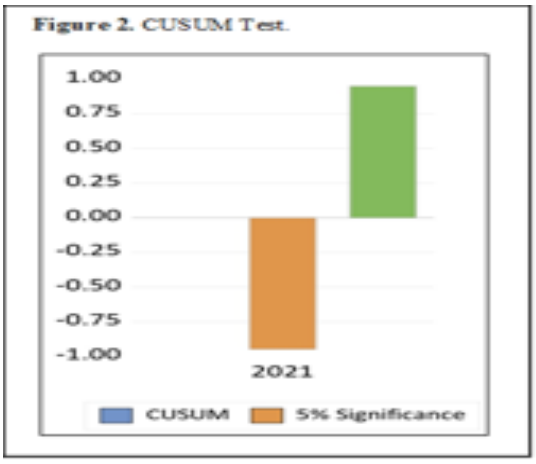
Our study utilizes Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests to examine the stability of the relationships between renewable energy consumption, GDP, and other economic variables from 2000 to 2021. These tests were necessary due to significant policy initiatives launched in 2019 aimed at enhancing renewable energy consumption in Saudi Arabia. We hypothesized that these initiatives could have altered the underlying economic dynamics.

The CUSUM tests revealed a notable crossing of the critical bounds in 2021. This crossing indicates a structural break in the regression model, suggesting that the underlying relationships among the studied variables have changed. The timing corresponds with the implementation of national renewable energy initiatives, pointing to a potential causative impact of these policies on the economic dynamics captured by our model. The CUSUM plot (Figures 4) shows a significant deviation beyond the 5% significance bounds, affirming the presence of instability in the parameter estimates of our model post-2019.

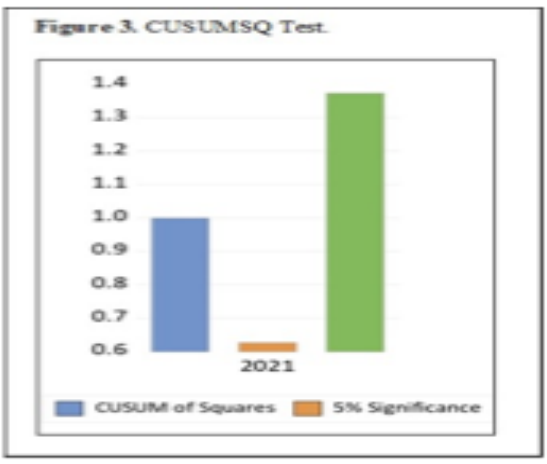
Similarly, the CUSUM of Squares tests (Figures 5), which focus on detecting variance instability in the regression model, also indicated changes post-2019. The test results in 2021 surpassed the significance bounds, suggesting alterations not only in the mean (as detected by the CUSUM test) but also in the volatility of the model errors. This variance instability likely reflects the economic impacts of the rapid scale-up in renewable energy projects and associated policy shifts.

In summary, the structural stability tests (CUSUM and CUSUMSQ) revealed significant breaks in 2021, likely due to policy changes related to renewable energy. These breaks had a substantial impact on the economic relationships modeled, highlighting the influence of recent renewable energy policies on Saudi Arabia's economic dynamics.

Figure: 4: CUSUM Test



5: CUSUMSQ Test



The analysis highlighted several critical findings:

Key Findings

Impact of Renewable Energy

Renewable energy consumption emerged as a highly significant factor positively affecting GDP. This underscores the effectiveness of Saudi Arabia's renewable energy initiatives in driving economic diversification and sustainable development in Saudi Arabia. This finding aligns with previous research by Amran et al. (2020) and Berradia et al. (2023), who emphasized the potential of renewable energy to drive economic growth and diversification.

Role of Foreign Direct Investment (FDI):

The analysis revealed a complex relationship between FDI and GDP. While FDI showed a negative impact in the short term, it was a significant predictor of future GDP growth. This suggests that the initial phases of FDI involve adjustment periods before yielding long-term economic benefits. This is consistent with findings from El-Awady (2020) and Azam et al. (2023), who highlighted the strategic role of FDI in driving economic diversification. However, exports did not show significant causality with GDP, indicating that while they are a major component of the economy, their direct predictive power on GDP is limited. This finding suggests that Saudi Arabia's economic diversification efforts should focus more on enhancing the investment climate and integrating FDI into various sectors to stimulate broader economic growth.

Government Expenditure:

Government consumption Expenditure consistently had a positive impact on GDP, emphasizing the importance of fiscal policy in driving economic activity. This is in line with the findings of Anghelache (2011) and Tulsidharan (2006), who highlighted the significant role of government spending in economic stability and growth. However, the lack of significant causality between government consumption and GDP indicates that while government spending supports immediate economic output, it may not be a strong predictor of long-term economic growth. This highlights the need for balanced fiscal policies that not only stimulate the economy in the short term but also create conditions for sustainable growth.

Dynamic Interactions and GDP Growth:

The VAR model revealed significant interactions between FDI, renewable energy consumption, government consumption expenditure, exports, and GDP growth, indicating that these factors collectively drive economic performance in Saudi Arabia. These dynamic interactions underscore the importance of strategic investments in renewable energy and other key sectors, supporting the broader Vision 2030 goals of economic diversification and sustainability. This alignment is further corroborated by studies such as those by Rafindadi et al. (2023) and AL-Tamimi et al. (2023), which emphasize the critical role of sustainable practices and economic resilience in achieving long-term growth and stability.

Structural Stability

Detailed sector-specific analyses, particularly on renewable energy projects, have revealed the nuanced impacts of FDI and government expenditure, emphasizing the necessity for targeted investments. These findings align with sector-specific recommendations made by Euchi (2018) and Abaker (2019) on enhancing education, fostering entrepreneurship, and developing tourism as pillars of economic diversification. Furthermore, the detection of structural breaks around 2021, which correspond with major renewable energy initiatives, suggests significant shifts in economic dynamics due to these policies. This observation is supported by the Oxford Institute for Energy Studies (2020) and other studies, highlighting the transformative impact of recent policy changes on Saudi Arabia's economic framework. These findings underscore the need for updated models to account for new policy impacts and support the strategic focus on renewable energy investments to achieve long-term economic stability and growth.

6.Conclusion and recommendations

This study provides a comprehensive understanding of the dynamic interactions between FDI, renewable energy consumption, government consumption, and exports, and their impacts on Saudi Arabia's GDP growth from 2000 to 2021. The key findings and their implications are detailed below:

Impact of Foreign Direct Investment (FDI) on GDP

The OLS regression results show that FDI has a positive and statistically significant impact on GDP growth. This finding aligns with the Eclectic Paradigm, suggesting that FDI brings in capital, technology, and management expertise, contributing to economic growth. The increase in FDI net inflows, especially in sectors such as technology, renewable energy, and infrastructure, highlights the effectiveness of policies aimed at attracting foreign investment. Policymakers should continue to enhance the investment climate to sustain and increase FDI inflows.

Role of Renewable Energy Consumption

The analysis reveals that renewable energy consumption positively affects GDP growth.

This result is consistent with the Diffusion of Innovations Theory, which explains how adopting new technologies can drive economic performance. Major projects like the Sakaka solar power plant and the Dumat Al Jandal wind farm have significantly contributed to this positive trend. These findings support the Vision 2030 goal of generating 50% of electricity from renewable sources by 2030. Policymakers should focus on removing barriers and providing incentives for renewable energy investments to further enhance their positive impact on the economy.

Government Consumption and Economic Stability

Government consumption expenditure shows a positive relationship with GDP growth. This finding underscores the importance of government spending in stabilizing and stimulating economic activity. Targeted government spending in infrastructure, education, and technology sectors can lead to long-term economic benefits. Policymakers should ensure efficient allocation of resources to these critical sectors to maximize their contribution to economic growth.

Exports and Economic Diversification

While exports remain a vital component of Saudi Arabia's economy, their direct impact on GDP growth is less pronounced compared to FDI and renewable energy consumption. The results suggest that the economy's over-reliance on oil exports makes it vulnerable to global oil price fluctuations. Diversifying exports to include petrochemicals, mining, and technology can provide more stable revenue streams. This diversification is essential for enhancing economic resilience and stability.

Interactions Between Economic Indicators

VAR model results indicate significant interactions between FDI, renewable energy consumption, government consumption, and exports. These interactions suggest that policies promoting one economic indicator can have cascading effects on others. For example, encouraging FDI in renewable energy projects can simultaneously boost GDP growth and support sustainable development goals. Policymakers should adopt integrated economic strategies that leverage these interactions to achieve holistic economic growth.

Structural Changes Following Renewable Energy Policies

One of the novel contributions of this study is the identification of structural changes in economic relationships following major renewable energy policy initiatives introduced in 2019-2020. The findings indicate that these policy changes have significantly altered the dynamics between FDI, renewable energy consumption, and GDP growth. This empirical evidence highlights the transformative impact of renewable energy policies on economic growth. Policymakers should continue to support and expand these initiatives to sustain long-term economic benefits.

Policy Implications

The study provides actionable insights for enhancing FDI and renewable energy investments, supporting sustainable economic growth. These recommendations are crucial for Saudi Arabia as it diversifies its economy and reduces reliance on oil revenues.

Policymakers should:

Simplify business procedures, offer tax incentives, and ensure political and economic stability to attract more FDI, essential for diversifying the economy.

Provide financial incentives, remove barriers, and improve infrastructure to encourage investments in renewable energy. This will support economic growth and help achieve the Vision 2030 goal of generating 50% of electricity from renewable sources by 2030.

Consider the combined effects of FDI, renewable energy, government consumption, and exports to achieve holistic economic growth. Encouraging FDI in renewable energy projects can boost GDP growth and support sustainable development goals.

Ensure that government spending targets sectors promoting long-term economic growth, such as infrastructure, education, and technology. Efficient resource allocation in these sectors can lead to substantial economic benefits.

Reduce dependency on oil by developing sectors like petrochemicals, mining, and technology. Diversifying export commodities and markets will provide more stable revenue streams and reduce vulnerability to global oil price fluctuations.

The practical significance of this research lies in providing actionable insights that align with Saudi Arabia's Vision 2030 objectives. By

highlighting the interconnectedness of FDI, renewable energy, government spending, and exports, the study offers a comprehensive framework for policymakers to craft strategies driving sustainable economic growth.

Policy Recommendations

The significant positive relationship between renewable energy consumption and GDP growth highlights the need to expand initiatives like the Sakaka solar power plant and the Dumat Al Jandal wind farm. Prioritize the NEOM project for its 100% renewable energy plan by integrating advanced technologies and sustainable practices.

Implement funding mechanisms such as feed-in tariffs, green bonds, and public-private partnerships to provide stable funding sources and incentivize private investment in renewable energy.

Improve the investment climate by reducing the time and cost of obtaining business licenses, streamlining construction permits, and enforcing anti-bribery laws. Establish specialized commercial courts for quick and fair resolutions to commercial disputes.

Mitigate risks associated with oil market volatility by developing sectors like petrochemicals, mining, and renewable energy. This diversification will provide alternative revenue streams less susceptible to global oil price fluctuations.

Incorporate trends from the global oil market into export strategies. Understanding and anticipating oil price fluctuations can help tailor policies to mitigate adverse effects and leverage favorable conditions for maximizing economic benefits.

Conduct detailed analyses to uncover the nuanced impacts of FDI and government expenditure within domains like renewable energy, technology, and healthcare. Analyze the role of FDI in renewable energy projects for sector-specific insights.

Improve regulatory frameworks, ensure political stability, and offer incentives to sustain FDI. Encourage strategic partnerships with foreign firms for technology transfer, management know-how, and access to global markets. Foster local enterprise development, particularly SMEs.

Optimizing Government Spending Efficiency by Focusing on sectors like technology, renewable energy, and education. Enhance fiscal policy flexibility and promote public-private partnerships in large-scale projects. Monitor and evaluate the long-term outcomes of public investments to ensure alignment with national goals.

By Investing in solar and wind projects, upgrade grids and storage solutions, and establish robust regulatory frameworks. Support research and development, form partnerships with global entities, and develop educational programs for local expertise. Ensure long-term policy support through incentives like tax breaks, subsidies, and guaranteed pricing for renewable energy output.

Limitations

While the current study provides significant insights, several key limitations should be addressed in future research:

The analysis did not incorporate IRFs, which could offer a deeper understanding of the dynamic responses of GDP to shocks in FDI, renewable energy consumption, government expenditure, and exports. Future studies should consider using IRFs to capture these temporal dynamics and potential lagged effects.

The study relies primarily on data up to 2021, which may not fully reflect the latest economic developments and policy impacts. Significant changes and implementations, particularly those associated with Vision 2030, have likely continued beyond 2021. This includes advancements in renewable energy projects, new FDI inflows, and additional government expenditure programs. The absence of post-2021 data means the study may not capture the full impact of these developments, potentially leading to gaps in analysis and conclusions. Incorporating more recent data would provide a more accurate and up-to-date understanding of Saudi Arabia's economic landscape.

The models used might not account for all potential influencing factors, such as technological advancements and international trade agreements. The detection of structural breaks, especially around 2019-2021, suggests that the models may not fully account for evolving economic dynamics. Future studies should consider re-specifying models to handle these breaks using methods like dummy variables or segmented regression techniques.

The analysis assumes stationarity and linearity in the time series data. Although differencing techniques were used to achieve stationarity, some non-linear relationships, especially in renewable energy consumption, might not have been fully captured. Future research should explore non-linear models to better understand these dynamics.

By addressing these limitations, future research can build upon the current study's findings to provide a more comprehensive understanding of Saudi Arabia's economic landscape and the factors driving its development.

Future Research Directions

Building on the findings and limitations of this study, several avenues for future research are recommended to further understand and enhance Saudi Arabia's economic development, particularly in relation to renewable energy, FDI, and government expenditure:

Including more recent data beyond 2021 will help validate and extend the current findings. Future research should aim to include data from subsequent years to assess the ongoing impacts of recent economic and policy changes.

Future research should incorporate advanced techniques such as rolling regression analysis and segmented regression models to better capture the impacts of policy shifts and structural changes identified post-2019.

To enhance model relevance and predictive power, future studies should integrate additional variables such as technological advancements, human capital development, and international trade agreements. Detailed studies focusing on specific sectors such as renewable energy, technology, and healthcare will reveal the nuanced impacts of FDI and government expenditure within these domains.

Analyzing the specific conditions under which FDI positively influences economic growth will provide deeper insights into attracting and sustaining foreign investments. Future studies should examine the impact of regulatory reforms, political stability, and market conditions on FDI inflows and their subsequent effects on the economy.

By pursuing these future research directions, scholars and policymakers can gain a deeper understanding of the complex dynamics at play in Saudi Arabia's economic development, leading to more effective strategies for achieving sustainable and diversified economic growth.

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Remittances and Economic Growth in North Africa: A Panel Cointegration Analysis

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Abstract: This article explores the short-term and long-term impacts of remittance inflows on economic growth in five North African countries (NAC): Egypt, Algeria, Tunisia, Morocco, and Sudan. Using annual panel data from 2000–2020 and employing the Panel Autoregressive Distributed Lagged (ARDL) model proposed by Pesaran et al. (1999), the research finds that remittance inflows have both significant long-term and short-term positive effects on economic growth. Specifically, a 1% increase in remittance inflows results in a 0.025% increase in economic growth. Additionally, other macroeconomic variables, such as capital formation and labor force participation, also contribute significantly to economic growth. The study reveals that in the long term, remittances promote investment activities, while in the short term, remittances primarily boost private consumption. The findings emphasize the need for policymakers to develop economic policies that encourage remittance inflows and direct them towards productive investment in the real economy. Recommendations include improving financial systems, reducing transaction costs, and implementing policies that stimulate remittance inflows for sustainable development.

JEL classification : *C30, C33, F24, F43, O55*
Keywords: *Remittance inflows, economic growth, migration, panel data, North African countries*

العلاقة بين التحويلات والنمو الاقتصادي في دول شمال إفريقيا: تحليل قياسي باستخدام منهجية التكامل المشترك للبيانات المدمجة

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المستخلص: يهدف هذا البحث إلى دراسة تأثيرات تدفقات الحوالات الخارجية على النمو الاقتصادي في خمس دول مختارة من دول شمال أفريقيا وهي كلا من مصر، والجزائر، وتونس، والمغرب، والسودان. استخدمت الدراسة للوصول إلى نتائجها البيانات المتاحة عن متغيرات الدراسة خلال الفترة من عام 2000 إلى 2020.لقد أظهرت نتائج الدراسة باستخدام نموذج الانحدار الذاتي الموزع ذو الفجوات الزمنية الموزعة المعروف في الأدبيات بـ (Panel Autoregressive Distributed Lagged (ARDL) model) أن الحوالات الخارجية لها تأثيرات إيجابية ومهمة على النمو الاقتصادي في البلدان المشمولة بالدراسة على المدى القصير والمدى الطويل. وبرغم أن الحوالات الخارجية توجهت بشكل رئيسي لتغطية النفقات الاستهلاك في المدى القصير، إلا أن نتائج الدراسة أوضحت أن تلك الحوالات تساهم في المدى الطويل في الأنشطة الاستثمارية التي تعزز الإنتاجية في اقتصاديات تلك الدول. لقد كشفت نتائج هذه الدراسة أن زيادة بنسبة 1% في الحوالات تؤدي إلى زيادة قدرها 0.025% في الناتج المحلي الإجمالي. من هنا توصي الدراسة لتعزيز هذه النتائج واستدامتها إلى ضرورة قيام صانعي السياسة في تلك الدول بتحسين وتعزيز الأنظمة المالية، تشجيع استخدام المنصات المالية الرقمية لخفض تكاليف المعاملات وزيادة الشفافية في تدفقات الحوالات وتقليل تكاليفها والحد من الآثار السيئة لقنوات الحوالات غير الرسمية، وتعزيز الشراكات بين القطاعين العام والخاص بما يسهم في توجيه الحوالات إلى الاستثمار في البنية التحتية والمشاريع الاقتصادية المنتجة. وضرورة مواءمة استراتيجيات التنمية الوطنية مع تلك الحوالات لتعظيم الفوائد الاقتصادية والاجتماعية منها.

الكلمات المفتاحية: الحوالات الخارجية، النمو الاقتصادي، دول شمال أفريقيا، الانحدار الذاتي ذو الفجوات الزمنية الموزعة.

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I. Introduction

The World Bank (2017) defined remittances as personal transfers either in cash or kind, workers' compensations, income from abroad, and short-term work. International remittances (IR) have grown in importance over the past decade and have taken the lead as the most prominent and vital external financial inflows to developing countries. The total volume of IR reached USD 773 billion in 2021. In 2020, the distribution of IR flows received by each region was as follows: 21.5% East Asia and Pacific, 20.85% South Asia, 14.76% Latin America, 12.55% Eastern Europe and Central Asia, 9.03% Middle East and North Africa, and 6.01% Sub-Saharan Africa (World Bank data, 2021a). Additionally, international remittance inflows represent a significant portion of international capital flows to labor-exporting countries, surpassing other types of flows, such as foreign direct investment, exports, and foreign aid, in terms of size and contribution to the economy (Jumiu & Husam, 2021; Ishaq Saidu1 & Ali Salisu, 2020; Mathew et al., 2022; Héla & Habib, 2020; Jumiu & Husam, 2021).

The importance of remittances is well documented in the economic literature. In the last few decades, remittance inflows have gained significant attention in labor-exporting countries due to their potential impacts on major macro and microeconomic variables (Moukpè & Essossinam, 2022; Adjei et al., 2020; Lawal et al., 2022; Al-Abdulrazag, 2018). Recent applied research revealed the role of remittance in affecting significant macroeconomic variables; for example, remittance inflows raise national income (Al-Abdulrazag & Abdel-Rahman, 2016), increase private consumption, promote investment activities (Azizi, 2018), increase production, increase employment opportunity (Al-Abdulrazag & Amani, 2014), and hence indirectly increase families' income, leading to a reduction in poverty level, among others (Prasiddha & George, 2021; Nyasha & Odhiambo, 2021; Al-Abdulrazag & Wahban, 2013). Specifically, the bulk of the applied research has focused on the remittance-economic growth nexus of recipient countries (Ishaq Saidu & Ali Salisu, 2020; Belesity, 2022; Héla & Habib, 2020; Mathew et al., 2022; Oluwasheyi, 2020; Jamiu & Husam, 2019). Kumar et al. (2018) argued that despite the importance of remittances as a vital source of income for migrants' families, it is often exposed to exchange risk and transaction costs (Jamiu & Husam, 2019). Therefore, the final impacts of remittance on EG could be ambiguous and depend on the final use by recipients for consumption or investment activities.

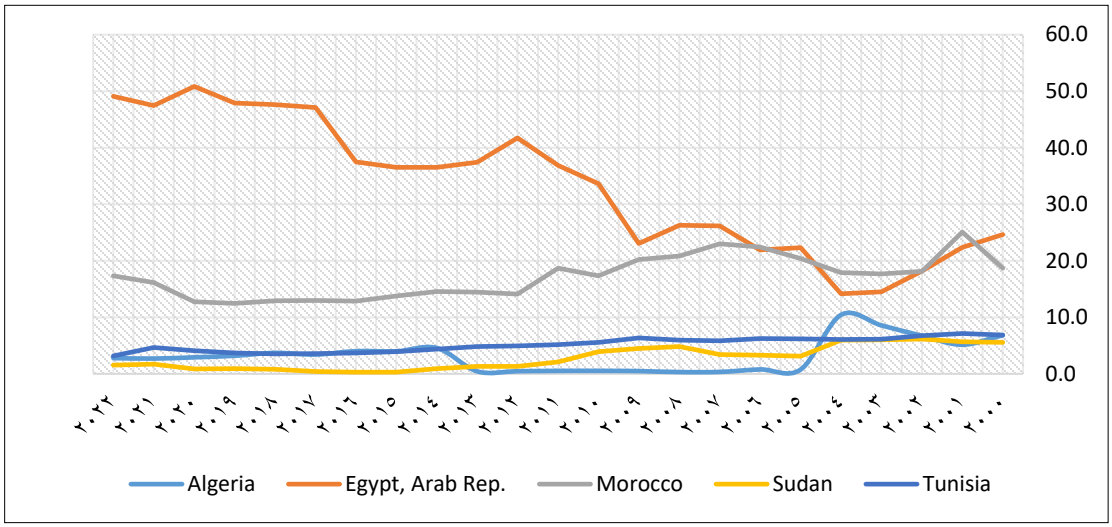
There is disagreement on the role of remittance inflows on the economic growth of the recipient countries. Some applied research reported a positive impact, others revealed a negative, and the rest found a neutral effect. The strand of empirical research that concluded that remittance inflows promote and enhance economic growth provided empirical evidence on the positive impacts of remittance inflows on economic growth (Ishaq Saidu & Ali Salisu, 2020; Jamiu & Husam, 2019; Mathew et al., 2022; Moukpè & Essossinam, 2022; Adjei et al., 2020; Héla & Habib, 2020; Oluwasheyi, 2020; Sutradhar, 2020; Kumar et al., 2018). They argued that remittances directly or indirectly affect economic growth by stimulating key significant macroeconomic variables (for example, private consumption, domestic investment, domestic saving, human capital, and trade), contributing to raising financing needed for sustainable development and economic activities. On the other hand, another stream of applied research concluded that remittance inflows could directly or indirectly negatively affect economic growth (Belesity, 2022; Nyasha & Odhiambo, 2021; Prasiddha & George, 2021; Jouini, 2015). Belesity (2022) argued that the direct negative impact of remittances on economic growth could be due to several reasons: (1) Remittances are considered an increase in recipient families' income without contribution, which hence leads to more leisure and less participation in the labor market; (2) the moral hazard problem arises due to the misuse of remittances from productive to unproductive uses. Another group of researchers indicated a neutral or insignificant nexus between remittances and economic growth (Mulatu, 2020).

This study intends to experimentally assess and explore the short- and long-term effects of remittances from foreign migrants on economic growth, along with some chosen macroeconomic

variables, in five chosen North African countries[c] including Egypt, Algeria, Tunisia, Morocco and Sudan utilizing the panel autoregressive distributed lag (ARDL) model introduced by Pesaran et al. (2001). Assessing the long- and short-term nexus between remittances and economic growth in those nations will also be aided by the Panel Cointegration Approach. We restrict our analyses to these five nations for two reasons: first, data availability; and second, because the nations we chose account between 52 and 73 percent of all the personal remittances that North African nations received during the study period, which ranged from roughly $11.6 billion in 2000 to $65.8 billion in 2020.

Figure (a) shows the relative share of the selected countries in the total personal remittances flowing into North African countries. Egypt obtained the most significant percentage among the selected countries, with a percentage ranging from 22% to approximately 50% during the entire period, followed by Morocco, which maintained its share of personal transfers at a rate that ranged around 18%, followed by Tunisia with a rate of not less than 3%, and then Sudan, at a rate that ranged from 6% as a maximum to 1.5% as a minimum during the entire period. Algeria also obtained varying percentages over time, ranging from 11% at its highest level to 3% at its lowest level.

Figure (a): Personal remittances flow into the selected North African countries, 2000–2022 (% of total personal remittances received by MENA countries)

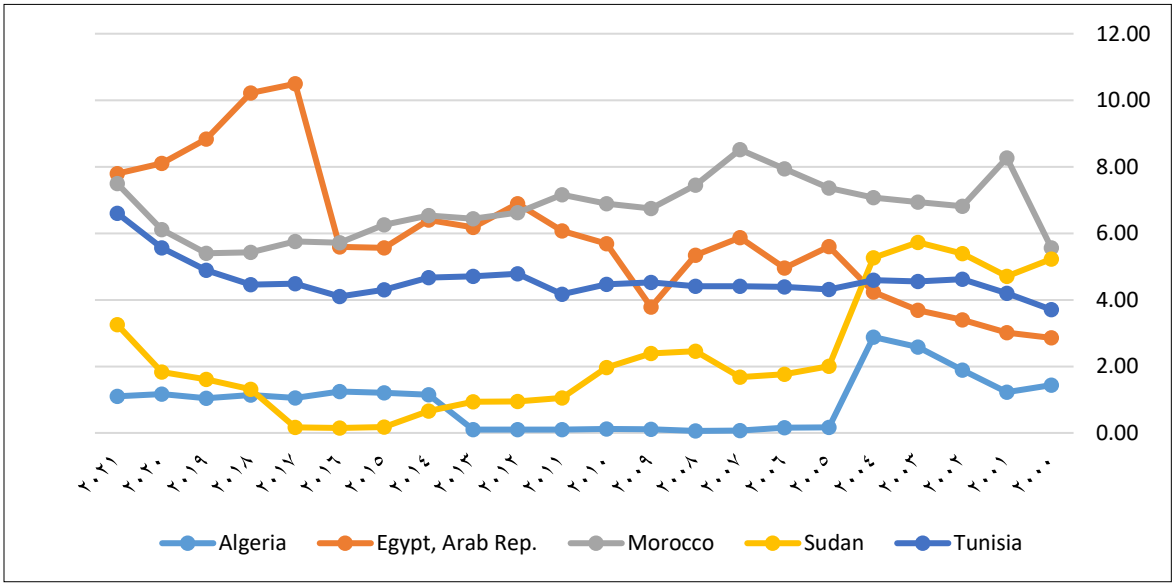


Source: World Bank database (https://data.worldbank.org/indicator/BX.TRF.PWKR.CD.DT).

More importantly, Figure (b) indicates the flow of personal remittances (PR) contribution to GDP in NAC. It can be observed that the PR contribution to the GDP in Egypt has been rising over the years and is equal to, on average, 7%. An argument has been raised by some economists, such as Ratha (2019), who believe that remittances will become the most significant external source of finance for developing countries. The same conclusion can be stated for the cases of Morocco and Tunisia. While PR contribution to the GDP in Algeria was only less than 2% from 2005 to 2021, PR contribution to the GDP in Sudan ranged from 5.7% in 2003 to approximately less than 1% in 2015 and returned to more than 3% in 2021. The formal one is that Algeria is an oil-producing country, so there are fewer migrants. However, Sudan has been feasibly under global economic sanctions since 2006, so the PR went down all over the period.

[c] *The North African countries are Egypt, Sudan, Libya, Tunisia, Algeria, Morocco, Mauritania, and the Western Sahara.*

Figure (b): Personal remittances flow into the selected North African countries, 2000–2022 (% of GDP).



Source: World Bank database (https://data.worldbank.org/indicator/BX.TRF.PWKR.CD.DT).

Given the significant increase in remittance inflows to those countries, the literature on international migration and subsequent development effects in North African countries has increased. However, the results of the many applied studies are inconclusive or, at the very least, mixed. Consequently, the study was motivated by these conflicting empirical findings in the literature on the remittance-growth nexus in North African countries. In addition, the study was also motivated by the need to provide evidence on the vital role of remittances in economic growth. Moreover, there is still room for further investigation of the remittance-growth nexus.

The main empirical findings show that remittance inflows have significant long-run and short-run impacts on the economic growth of North African countries; moreover, the other macroeconomic variables have significant positive impacts. The estimation results revealed that a 1% increase in remittance inflows into NAC causes a 0.025% increase in economic growth.

The study contributes to the existing literature in many ways. Firstly, it focuses on five NAC from 2000–2020. In particular, the study investigates the direct impact of remittances on the economic growth of North African countries. This makes some economic sense because these countries possess similar characteristics.

Secondly, the study employed the system GMM estimator due to its practical advantage for the dynamic data set. Thirdly, the study contributes to the empirical literature on the macroeconomic implications of remittances in North African countries and, by extension, developing countries.

This paper is structured as follows: Section two presents the trends in remittance inflows to North African countries. Section three discusses literature reviews and the theoretical framework. Section four presents the methodology. Section five reports the results and discussion. Finally, section six presents the conclusion and recommendations.

2. Review of Literature

This section discusses the theoretical and empirical literature on remittance inflows' potential impacts on significant macroeconomic variables, concentrating on economic growth in selected North African countries.

2.1 Theoretical background

There has been a growing concern about the role of remittance inflows as a critical source of

external finance and their potential impact on significant macroeconomic variables in the receiving countries. In economic literature, two significant motives or factors cause labor movement across borders: the push and pull factors. Push factors are related to countries of origin (sending countries), while pull factors are associated with destination (labor-receiving) countries. Both factors almost share the same factors: economic, political, and cultural, among others. These factors include the income gap, employment opportunities, inequality, injustices, demographic imbalances, etc. Moreover, social exclusion, discrimination, political victims, corruption, a lack of education, health care, social security, and marriage opportunities

Over the last few decades, there has been a growing interest in the determinants of economic growth and significant macroeconomic variables (Vensa, 2020). Among these factors, as researchers, policymakers, and the public believed, remittances were an essential factor affecting economic growth, specifically in developing countries. Remittances impact economic growth through three channels. First, by improving the rate of capital accumulation, remittances increase the physical and human capital accumulation rate and lower the cost of capital in the recipient country. This may stabilize the economy and reduce volatility. The second impact is related to the subsequent change in labor force participation as remittance income is substituted for labor income. Third, remittances affect investment efficiency by impacting total factor productivity growth (Vensa, 2022; Jumiu & Husam, 2021; Oluwasheyi, 2020). In this regard, three competing theories were introduced in the economic literature to explain the impact of remittances on economic growth. First, the developmental-optimistic school This theory regards remittances as one of the significant factors in reducing poverty levels among recipient families and being used to finance trade, thereby affecting economic growth. Second, the pessimistic developmental school believes that the increased volume of remittances would increase the dependency level of the recipient countries on remittance inflows and, hence, negatively affect economic growth, leading to income inequality among the population. Third, the remittance development pluralists' theory argues that there is no strict optimistic or pessimistic view on the impact of remittances on economic growth. There needs to be a consensus or clear-cut consensus among researchers on the effect of remittances on economic growth. Therefore, it is the task of empirical work to clarify and solve the controversy among economists.

2.2 Empirical literature

A substantial amount of applied research has investigated the influence of remittances on economic growth in recent decades. Similar to the proposed theories outlined previously, applied research shows conflicting evidence on the influence of remittances and their long-term consequences in the origin countries, resulting in mixed empirical evidence. While some applied research supports the idea that remittances play a vital role in economic growth in recipient countries, specifically developing countries, others highlight negative findings, contrasting perspectives, and identify gaps for future research.

Here are some empirical studies indicating that remittances have a favorable impact on economic growth. Moukpè and Essossinam (2022) examined the effect of remittance on EG in ESCAWS countries over the period 1980–2017 by applying the seemingly unrelated regression method. The findings indicated a significant positive impact of remittances on economic growth in these countries.

Ishaq Saidu1 & Ali Salisu (2020) investigated the nexus between remittance inflows and economic growth in some selected sub-Saharan African countries using panel data from 1980-2018. Their empirical findings revealed a positive impact of remittances in connection with FDI, trade openness, and domestic investment on economic growth.

Using dynamic panel data techniques, Adjei et al. (2020) investigated the causality between remittances and EG in West Africa (Burkina Faso, Ghana, Guinea, Guinea-Bissau, Mali, Nigeria, and Togo). The empirical evidence revealed that remittances have a significant positive impact on the economy of West Africa.

Using panel regression, Vesna (2022) investigated the remittance-economic growth nexus in the South East European (SEE) countries

using quarterly data from 2008–2020. His findings revealed a significant positive impact of remittances on economic growth, thereby providing evidence of the validity of the remittances-growth hypothesis for SEE countries.

Mathew et al. (2022) examined the nexus between international remittances and per capita economic growth in Nigeria by employing annual time series data from 1980 to 2020 and adopting the ARDL bounds estimating model. The empirical findings revealed a significant positive impact of remittances on economic growth in both the long and short run.

Oluwasheyi (2020) examined the long-run and short-run impacts of remittances on Nigeria's economic growth, using quarterly data from 1970 to 2017, by applying the Johansen cointegration and the VECM approaches. The findings showed that remittances positively and significantly affect Nigeria's economic growth.

Sutradhar (2020) investigated the impact of workers' remittances on economic growth in four South Asian emerging countries using balanced panel data from 1977 to 2016. The results of the study revealed that remittances have a positive impact on economic growth in India.

Jamiu and Husam (2019) examined the long-run and short-run nexus between remittance and EG in MINT countries (Mexico, Indonesia, Nigeria, and Turkey) from 1990-2017 by employing the ARDL bounds test to cointegration. They concluded that remittance has a long-run positive impact on EG of MINT countries, except for Nigeria was negative.

Kumar et al. (2018) examined the nexus between remittances and economic growth in Kyrgyzstan and Macedonia from 1990 to 2015 by applying the ARDL. Their empirical findings revealed the positive impact of remittances on economic growth both in the long run and the short run. Moreover, the non-granger causality test provides evidence for the remittance-led growth hypothesis for Kyrgyzstan, supporting the EG-led remittances for Macedonia. In the long run, both financial development and remittances exerted a negative effect on per capita income. However, the latter was not statistically significant, and there was a negative correlation between remittances and financial development.

In contrast, some of the empirical researches demonstrating negative impact of remittances on economic growth. Belesity (2022) examines the impact of remittance inflows on the economic growth of 26 Sub-Saharan African countries, along with financial sector development, institutional quality, economic freedom, and others from 2010-2019. The empirical findings using the two-step system GMM revealed that remittance inflows negatively impact economic growth.

Lawal et al. (2022) explored the intricate relationship between economic growth and various factors such as exchange rates, remittances, trade, and agricultural output, utilizing data collected from 1980 to 2018 across ten selected African economies. Results from the time-domain test suggests no significant relationship between economic growth and both remittances and agricultural output and the causality only exists between economic growth and both exchange rate and trade.

Nyasha and Odhiambo (2021) examined the impact of remittances on the EG of South Africa from 1970 to 2019 by applying the autoregressive distributed lag (ARDL) bounds testing approach. Their findings showed a significant negative impact of remittances on economic growth in both the long and short run.

Prasiddha & George (2021) examined the impact of remittance on the economic growth of Nepal over the period 1976-2019 by applying the J-J cointegration and VECM methods. The main finding is that remittance significantly negatively impacts the EG of Nepal.

On the other hand, Mulatu (2020) among others found mixed results when he studied the short-run and long-run nexus between remittance inflows of international migration and economic growth in three selected economies, Ethiopia, Kenya, and Uganda, for the period 1990–2017 by applying the pooled modified least squares (FMOLS) estimation approach. The results of the study provide significant evidence for the remittance-led growth hypothesis, but the results showed an insignificant long-run positive impact of remittance inflows on economic growth.

These contradictory results could be due to several factors, such as whether the study was applied to a single or multi-country context, research methodology, data type (time series or panel), the covered period, whether the countries are developed or developing, income

classification, and the effectiveness of government policies used to redirect those remittances. In fact, the impact of remittances on growth is often conditional on factors like how the funds are used, government policies, and the overall economic context (Chami et al., 2008). Research suggests that remittances can positively influence economic growth by stimulating consumption, fostering investment, and promoting entrepreneurship (Ratha, 2020). However, over-reliance on remittances can lead to Dutch disease, a phenomenon where currency appreciation hinders export competitiveness and industrial development (Aizenman, 2009).

The impact of remittances on economic growth in North African countries has been a subject of ongoing research and debate. Recent literature explores the multifaceted nature of this relationship. Here's a summary of key findings from recent available literature:

1. **For the significance of remittances**: Studies consistently highlight the high dependence of North African economies on remittances, with countries like Morocco, Algeria, and Egypt receiving significant portions of their GDP from these inflows. (World Bank, 2022). Remittances remain a crucial source of income for many households, contributing to consumption, poverty reduction, and overall economic well-being (Ratha, 2020).
2. **For the impact on economic growth**: A few empirical studies analyze the impact of remittances on the economic growth of each of the selected North African countries, and the findings can be summarized as follows: In Algeria, Research on the relationship between remittances and GDP growth in Algeria provides mixed evidence. For example, Abdelkader and Benhabib (2014) found a positive and statistically significant correlation between remittances and GDP growth, suggesting that remittances contribute positively to Algeria's economic expansion. But Bouarfa and Meziani (2018) argued that the relationship is complex and depends on factors such as the sector of the economy and the recipient's characteristics. In another recent study, Khediri and Aït-Sahalia (2017) highlighted the need to consider other macroeconomic factors alongside remittances, such as government policies and oil prices.

- In Egypt, several studies suggest a positive correlation between remittances and GDP growth in Egypt. For example, El-Sakka et al. (2017) found that remittances contribute significantly to Egypt's economic growth, with a 1% increase in remittances leading to a 0.2% increase in GDP. Another study by Mahmoud and El-Ashry (2019) concluded that remittances are a vital driver of economic growth, particularly in non-oil sectors.
- In Morocco, the impact of remittances on GDP growth in Morocco has been studied extensively, with mixed results. Whereas, Benhima and El-Attar (2013) found a positive and significant correlation between remittances and GDP growth, suggesting that remittances contribute positively to Morocco's economic expansion. And Rachid and Chakir (2017) also highlighted the importance of considering the impact of remittances on other macroeconomic indicators like inflation and unemployment. Alaoui and Benhima (2018), however, argued that the relationship is less straightforward and depends on various factors, such as the sector of the economy and the recipient's characteristics.
- In Sudan, while some studies suggest a positive relationship between remittances and GDP growth in Sudan, evidence is not conclusive. For example, Ahmed and El-Hassan (2016) found a positive and statistically significant impact of remittances on GDP growth, concluding that remittances contribute significantly to Sudan's economic growth. However, Al-Amin and El-Tom (2018), argued that the impact of remittances on GDP growth is less pronounced due to structural constraints in the Sudanese economy, including limited access to financial services and a weak institutional framework.
- In Tunisia, Studies on the impact of remittances on GDP growth in Tunisia have yielded mixed results. For example, Ben Youssef and El-Hani (2014) found a positive and statistically significant correlation between remittances and GDP growth,

suggesting that remittances contribute positively to Tunisia's economic expansion. Also, Sellami and Boujelbene (2017) emphasized the importance of considering the impact of remittances on other macroeconomic indicators alongside GDP, such as inflation and unemployment. While, a recent study by Ayadi and Ben Ameur (2018), found that the relationship is complex and depends on various factors, such as the sector of the economy, the recipient's characteristics, and government policies.

Another stream of studies considering more than one of the selected north African countries found mixed results. For example, Jouini et al. (2021) applied the cointegration approach to data from 1970–2009 to examine the remittances-economic growth nexus of two North African countries, Algeria and Morocco. The empirical findings conflicted in the short-run and long run for Algeria, where the nexus was negative in the long run. However, in the short run, remittances affect EG through human capital and financial development. On the other hand, for Morocco, only in the long run was their evidence for the remittance-growth hypothesis, and no causal link was found in the short run. Héla, M. and Habib, O. (2020) investigated the role of the financial sector as a channel through which migrants' remittances could affect EG in some selected MENA regions, namely Algeria, Egypt, Iran, Jordan, Lebanon, Morocco, Sudan, Tunisia and Turkey, during the period 1990-2018 by applying the GMM estimation approach. Their empirical findings revealed the positive impact of remittances on EG in those selected MENA countries.

The study contributes to the existing literature in many ways. Firstly, it focuses on five North African countries from 2000–2020. In particular, the study investigates the direct impact of remittances on the economic growth of North African countries. This makes some economic sense because these countries possess similar characteristics and account for more than 52% of the total amount of IR received by the North African countries. Secondly, the study employed the system GMM estimator due to its practical advantage for the dynamic data set. Thirdly, the study contributes to the empirical literature on the macroeconomic implications of remittances in North African countries and, by extension, developing countries.

3. Methodology and data

3.1 The Theorical Model and data

This study explores the impact of remittance outflows and foreign direct investment (hereafter FDI) on economic growth in selected North African countries by using an extended production function where remittances and FDI are included as macroeconomic factors. The primary economic growth model can be written as follows:

$$GDP_{it} = f(K_{it}, L_{it}, REM_{it}, FDI_{it}) \quad (1)$$

As each variable is expressed in its natural logarithmic form, and after adding a random error term, the empirical model takes the following form:

$$LGDP_{it} = \beta_0 + \beta_1 LK_{it} + \beta_2 LL_{it} + \beta_3 LREM_{it} + \beta_4 FDI_{it} + \varepsilon_{it} \quad (2)$$

Where GDP_{it} is the real gross domestic product (measured in milliards of constant 2015 US dollars), K_{it} is the gross fixed capital formation (measured in millions of constant 2015 US dollars), L_{it} is the labor force (measured in millions), FDI_{it} is the stock of FDI (measured in millions of constant 2015 US dollars). Moreover, REM_{it} is the remittance inflows (measured as a percentage of GDP), ε_{it} is the stochastic error term, $_{\mathrm{I}}$ refer to the country, and t refers to the period for each country. All variables are converted into natural logarithms, so the estimated coefficients represent the elasticities of real GDP with respect to the dependent variable. Finally, the panel cointegration techniques are used to investigate the long-run dynamic effects between economic growth, remittance outflows, and FDI in a cointegration relationship between variables.

The data set used in the study is annual and extends from[d] 2000 to 2020 for the selected five North African countries: Algeria, Egypt, Morocco, Sudan, and Tunis. Data are collected

[d] *The period is chosen according to data availability for all selected countries; therefore, the panel is balanced.*

from the World Development Indicators (WDI) and United Nations Conference on Trade and Development (UNCTAD).

3.2 The Econometric Model

The study employs the Pooled Mean Group (PMG) estimation approach[e] Pesaran et al. (1999) estimate the dynamic heterogeneous panel model, which includes the short-run and long-run causal linkages between economic growth and foreign direct investment and remittance outflows. The estimated model takes the form of the Autoregressive Distributed Lag (ARDL) model, which allows for estimating the short-run and long-run relationship. The model takes the following specification:

$$\Delta Ly_{it} = \phi_i(y_{i,t-1} - \gamma_i' X_{i,t-1}) + \sum_{j=1}^{p-1} \beta_{ij}' \Delta Ly_{i,t-j} + \sum_{j=0}^{q-1} \Delta X_{i,t-j} \delta_{ij}' + \mu_i + \varepsilon_{it} \quad \textbf{(3)}$$

Where L and Δ stands for the natural logarithm and the first difference operator, respectively. ΔLy_{it} and ΔX_{it} are, respectively, the first differenced real GDP and the set of dependent variables (capital, labor, foreign direct investment, and remittances), $\emptyset_i$ is the term of error-correcting speed of adjustment. The vector of coefficients γ contains coefficients of the long-run relationship between variables which are assumed to be identical across countries, the vector of coefficients β captures the short-run past own effects of real GDP, the vectors of coefficients δ measure the short-run impacts of the dependent and α_i are the individual specific effects. The optimal lag orders P and q are selected using the Schwarz Bayesian information criterion (SBC).

We should at this point clarify that the reason behind our selection of the Panel ARDL approach over alternative models, such as fully modified OLS or dynamic panel models was driven by several key considerations specific to our study's objectives and data characteristics. First of all, the primary focus of the analysis is to explore both the short-term and long-term impacts of remittance inflows on economic growth. The ARDL model excels in this regard, as it can estimate both short- and long-run relationships simultaneously. Other FMOLS methods focus on long-run dynamics and may not capture short-run effects as effectively. Second, the presence of cross-sectional dependency across the countries studied was confirmed through diagnostic tests. The Pooled Mean Group (PMG) estimator within the ARDL framework is designed to handle this dependency, ensuring more accurate and unbiased results. Other estimation techniques, such as FMOLS, may lead to biased estimates when cross-sectional dependency is present. Third, the ARDL model allows to capture the dynamic relationships between variables over time, and it ensures the robustness of our estimates. Finally, as for robustness tests, we conducted panel unit root and cointegration tests to validate the appropriateness of the model, and we ensured that the selection of lag lengths was done systematically to avoid overfitting. Cross-sectional dependence tests were also carried out to confirm the presence of dependencies, further justifying the use of the ARDL approach. Also, according to Pesaran et al. (1999), the PMG estimation methods provides robust estimation results of the long-run relationship under the homogeneity assumption and overcomes endogeneity and serial correlation.

4. Empirical results and findings

The initial step in the empirical study is to examine the stationarity properties to determine the order of integration of the used variables. Next, the panel cointegration tests are employed to check for long-run relationships among variables. The integration properties of the variables and cointegration tests allow for determining the appropriate econometric methods to be used in the empirical analysis. Finally, if a long-run cointegration relationship is found, the cointegrated panel estimation methods are applied to investigate the linkages between the variables.

4.1 Data and summary statistics

The study uses annual data for real GDP, capital, labor, foreign direct investment, and remittance outflows for a panel of five North African countries from 2000-2020. Table 1 summarizes the descriptive statistics for each variable.

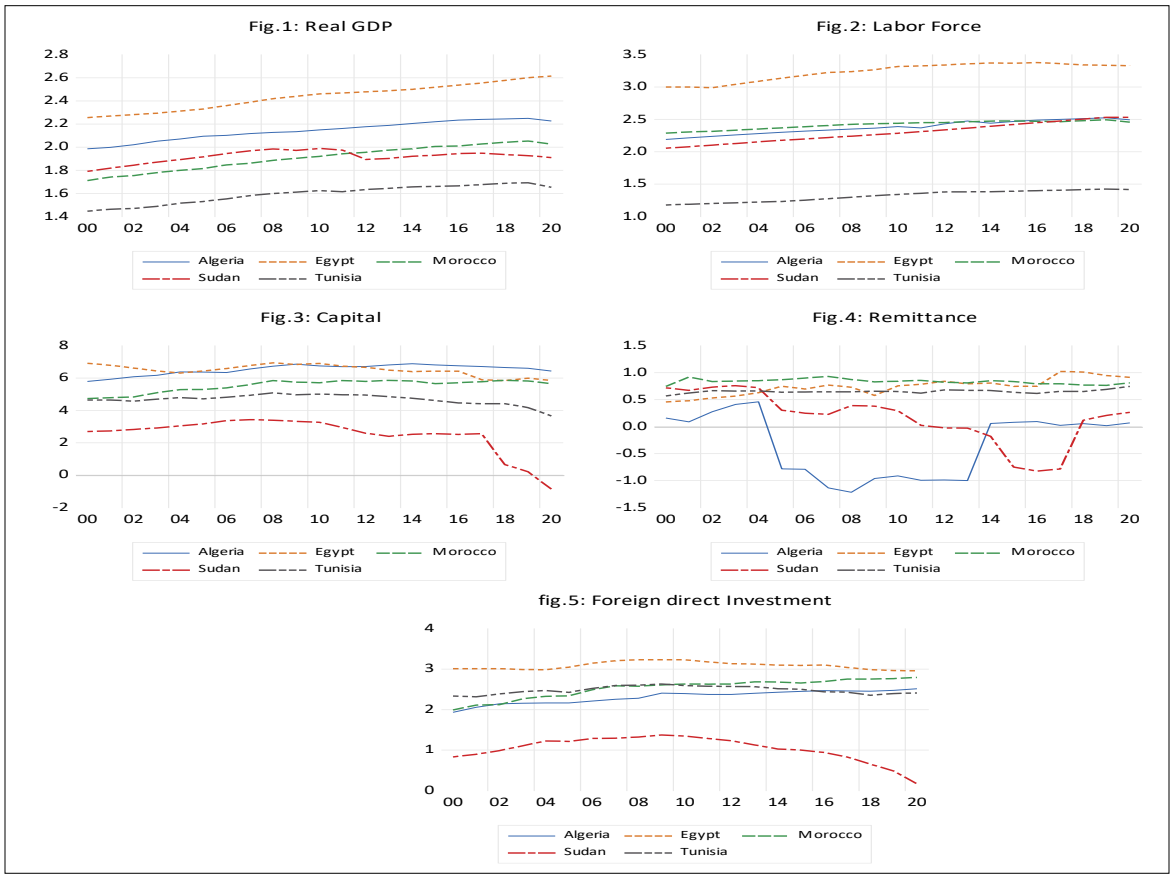
[e] *Pesaran et al. (1999) indicate that the PMG estimation technique provides a consistent and efficient estimated coefficient of the long-run relationship under the homogeneity assumption.*

The log levels of the real gross domestic product (GDP), the gross fixed capital formation (K), the labor force (L), foreign direct investment (FDI), and remittance outflows (REM) are plotted in Figs. 1–5, respectively. We observe a common trending behavior, indicating some relationship between the variables. Furthermore, the figures show that all variables have increased over time for all countries. Egypt has the highest real GDP, labor force, and FDI, Tunisia has the lowest real GDP and labor force, and Sudan has the lowest FDI.

Table 1: Summary statistics

Variables	Mean	Max	Min	Std.
GDP	125.65	412.246	27.97	91.555
Capital	12.303	29.254	3.245	7.456
Labor	359.04	1033.94	0.426	320.575
FDI	4.074	10.494	0.061	2.600
Remittanc	432.15	1701.69	1.444	448.973

Figs. 3 and 4 reveals that the highest remittance value (capital) inflows are in Morocco (Algeria), while the lowest capital and remittance inflows are observed in Sudan. The drop in Sudanese remittances from 2004–2012 is attributed to the world economic sanctions led by the USA from 1988–2007 and the global financial crises (Atif & Abdalla, 2018). This action affected the Sudanese's economic activities, such as the agricultural, industrial, and financial sectors. Due to the sanctions on international financial activities and the gap between the formal exchange rate and the informal (black market) exchange rate, the formal flow of remittances has declined, which has led to the flourishing of informal channels (Ishag, 2023; Cohen et al., 2012).



4.2 The panel unit root tests

The variables' non-stationarity analysis and integration properties are a priority for conducting empirical studies, which allows for determining the appropriate estimation method. For panel data, a wide range of panel unit tests (Maddala & Wu, 1999; Breitung, 2000; Hadri, 2000; Levin, Lin, and Chu, 2002; Pesaran & Shin, 2003) are developed to examine variables' integration order. However, these unit root tests deal with the issues of homogeneity and heterogeneity among pooled cross-sectional data. Therefore, in the presence of significant contemporaneous correlation among cross-sections, the panel unit root tests cited previously can have low power and lead to misleading results. Within this context, the cross-section dependence (CD) test has been developed by Pesaran (2004), which allows for verifying the existence of such dependence for cross-section panel data. The CD test is constructed to test independence under the null hypothesis against dependence under the alternative hypothesis. In addition, Pesaran (2007) proposes a second generation of panel unit root tests incorporating cross-sectional dependency. The panel unit-root test of Pesaran (2007), referred to as the CIPS test, is constructed under the null hypothesis of a unit root against no unit root under the alternative hypothesis.

The results of the CD test and CIPS unit root test are reported in Table 2. The CD test results strongly reject the null hypothesis of cross-sectional independence at the 1% level. Furthermore, according to the CIPS test, each variable contains a unit root but no unit root at the first difference, I(1).

Table 2: CD test and CIPS unit root test results

	CD test	CIPS test	
Variables	**CD statistics**	**Level**	**First differences**
GDP	11.503* (0.000)	-1.036 (0.952)	-5.427* (0.000)
K	13.761* (0.000)	-2.525 (0.303)	-3.561* (0.002)
L	4.437* (0.000)	-1.544 (0.967)	-3.093** (0.036)
FDI	14.807* (0.000)	-2.288 (0.509)	-3.510** (0.000)
REM	5.351* (0.000)	-2.326 (0.484)	-2.604** (0.024)

*Notes: *, **, and ***denote the rejection of the null hypothesis at the 1%, 5%, and 10% significance levels, respectively. The values in parentheses are the P-Values. The critical value of the CIPS is provided in Pesaran (2007), Section 4, Table II(b) and II(c), pages 280-281. The lag order p is selected based on the AIC with a maximum delay order equal to 4. The "xtcdf" and "pescadf "stata commands are used to perform CD and CIPS tests.*

4.3 Panel cointegration analysis

The panel unit root test results indicate that all variables are integrated in order one. Consequently, the panel cointegration tests explore the long-run relationships between economic growth, foreign direct investment, and remittance outflows. Many panel cointegration tests have been developed and used to test for cointegration in panel data. For example, Kao (1999) proposes ADF-type tests for cointegration under the assumption of endogeneity between variables, while Pedroni (1999, 2004) proposes several tests for cointegration, allowing for heterogeneity.[f] [1]. However, using the classic panel cointegration test, the first-generation cointegration test can produce misleading results in cross-sectional dependency. Hence, the second-generation panel cointegration tests deal with cross-sectional dependency and provide evidence about cointegration relationships among variables. In this context, the panel cointegration test developed by Westerlund (2007) is conducted to explore

[f] *The results of the panel cointegration tests of Kao (1999) and Pedroni (2004) strongly reject the null hypothesis of no cointegration. Unfortunately, the obtained results are not reported but are available upon the authors' request.*

evidence of cointegration between variables. The obtained results of the panel cointegration test are reported in Table 3 and reveal that the null hypothesis is firmly rejected at the 5% significance level, implying evidence of a long-run relationship between variables.

Table 3: Results of panel cointegration test

Tests	Statistic	Z. Values	P. Values
Gt	-18.082	1.364	0.000*
Ga	-16.036	1.081	0.000*
Pt	-5.360	-2.457	0.007*
Pa	-6.485	-1.819	0.035**

Notes: *The Stata commends "twist" is used to perform Westerlund's (2007) cointegration test. The panel cointegration test of Westerlund (2007) is constructed under the null hypothesis of no cointegration. The optimal lag and lead lengths for each series are selected using AIC, * and ** * and ** denote significance at 1% and 5% significance levels, respectively. The cointegration test is conducted with both constant and trend terms.*

4.4 Estimation results and findings

The above results of panel unit root and cointegration tests reveal that all variables are integrated of order one and are cointegrated; hence, the cointegrated panel estimation techniques are employed to estimate the short- and long-run linkages between economic growth, foreign direct investment, and remittance outflows. However, the OLS estimation method for the cointegrated panels leads to spurious regression. In addition, the DOLS method proposed by Kao and Chiang (1997) and the FMOLS estimation techniques developed by Pedroni (2001, 2004) are not appropriate to estimate the long-run cointegration relationship between the model's variables under cross-sectional dependency. Thus, the PMG estimation procedure is implemented to estimate the short-run and long-run relationships since it is the appropriate estimation technique under cross-sectional dependency (see, among others, Pesaran et al., 1999).

4.5 The results of the Long-run dynamics

The estimated results of the long-run relationship between economic growth, foreign direct investment, and remittance outflows using PMG are displayed in Table 4. The results reveal a positive and significant impact of capital on economic growth. In addition, we find that FDI and remittance inflows exert a significant and positive long-run effect on economic growth. The results indicate that a 1% increase in FDI leads to an increase of 0.128% in economic growth, and an increase of 1% in remittance inflows leads to an increase in real GDP of 0.025%.

Table 4: The PMG long-run estimate results

Variables	Coef.	T-statistics
L	0.016	0.178
K	0.181	4.095*
REM	0.025	3.548*
FDI	0.128	3.503*

*Notes: * and ** denote significance at 1% and 5% significance levels, respectively.*

4.6 Short-run dynamics and error correction mechanism

The estimated results of the long-run relationship between economic growth, FDI, and remittance inflows indicate that FDI and remittance significantly impact economic growth. Therefore, the study sought to explore the short-run linkages among variables and the adjustment speed toward long-run equilibrium. The estimated results of the short-run interactions are reported in Table 5. The results reveal that the factors of production (labor and capital) with one lag are positive and statistically significant. Furthermore, the estimated results of the short-run dynamic indicate that remittance inflows have a positive and insignificant effect on real GDP.

Table 5: The short-run estimates results and error correction

Variables	Coef.	t-statistics
DLGDP(-1)	0.011	2.343**
DLL	-1.784	-0.045
DLL(-1)	0.312	2.795*
DLK	-0.208	-0.835
DLK (-1)	0.061	2.283**
DLREM	0.013	4.162*
DLREM(-1)	0.004	2.267**
DLFDI	-0.087	-1.090
DLFDI(-1)	-0.024	-0.924
Adj. speed	-0.318	-1.779***

*Notes: "DL" indicates the first log difference, and "Adj. speed" is the error correction speed of adjustment. *; ** and *** denote significance at 1%; 5% and 10% significance levels respectively.*

In contrast, FDI has a non-significant impact on GDP. The short-run, insignificant impact of remittance inflows indicates that foreign

workers take some time to remit their income to their homeland. Moreover, the estimated result reveals a higher speed of adjustment, where the estimated error correction term is about 0.32 and is significant at the 5% level. This finding indicates that we need about three years to restore long-run equilibrium.

4.7 Discussion of the Estimated Results

The empirical results reveal important insights into the relationship between remittance inflows and economic growth in North African countries, both in the short run and the long run. This section will break down these findings more explicitly and highlight their policy implications.

Short-Run Results

In the short run, the analysis shows that remittances have a **positive but insignificant impact** on real GDP. This suggests that remittance inflows in the short term are primarily directed toward immediate consumption needs, such as household expenses and personal consumption. These findings are consistent with earlier studies (Mathew et al., 2022; Sutradhar, 2020) which indicate that remittances in developing countries initially stimulate consumption rather than investment activities.

The insignificant short-term impact of remittances on GDP can be explained by the time lag in the remittance process. Many migrant workers take time to remit their income back to their home countries, which delays the economic effects. Furthermore, the short-run dynamics show a positive effect of labor and capital on GDP, reinforcing the idea that these production factors play a more immediate role in driving short-term economic growth.

Long-Run Results

In contrast, remittances have a **significant and positive impact** on economic growth in the long run. The long-run elasticity of remittance inflows indicates that in the long run, a 1% increase in remittances corresponds to a 0.025% rise in real GDP. This suggests that over time, remittance inflows contribute to **investment activities** that enhance productive capacity. Migrants' remittances are increasingly directed towards more sustainable uses such as business ventures, real estate, and education, which positively influence total factor productivity.

This long-run positive effect aligns with previous studies (Ishaq Saidu & Ali Salisu, 2020; Jamiu & Husam, 2019) and reflects the shift from consumption to more productive uses over time. The findings highlight the potential of remittances as a long-term growth factor when properly channeled into investment and human capital development.

Finaly, both short-term and long-term impacts highlights the importance of remittances as a key driver of economic growth in North African countries. While their immediate effect may be limited to consumption, the long-run benefits through increased investment and productivity are significant. By implementing effective policies that promote the productive use of remittances we recommended in the conclusion, North African countries can better harness these funds for sustainable economic growth and poverty reduction.

5. Conclusion and policy implication

According to the results of the long-run cointegrating parameter estimations, an increase in remittances had a favorable and significant long- and short-term impact on the economic growth of the selected North African nations. This finding suggests that remittances are spent for productive purposes rather than personal consumption, such as genuine investment activities and the degree of human capital investment. Thus, we advise the North African nation under consideration to strengthen its domestic financial system and macroeconomic policies to foster an environment that attracts private and public investors and increase investment prospects in their economies. As the results indicate, a 1% increase in FDI leads to an increase of 0.128% in economic growth, and an increase of 1% in remittance inflows leads to an increase in real GDP of 0.025%. Furthermore, more remittances should be directed to the formal financial system rather than informal channels to achieve comprehensive growth. In other words, go from cash to digital and from unofficial to official routes to increase the benefits the chosen countries receive from their skilled and unskilled migration streams and anticipate stable economic conditions

in both the most advanced and the Gulf countries. Here are some significant policy implications for North African countries may leverage remittances for sustainable economic growth:

1. Strengthening the Formal Financial Systems: The study reveals that remittances have a significant impact on economic growth, especially when directed toward productive activities such as investment rather than consumption. Also, given the delay in short-run effects and the importance of formal financial channels in the long run, governments should strengthen financial systems to facilitate faster and more secure remittance transfers. Such that governance policy that enhances formal financial channels for remittances would increase the positive impact of these inflows. Governments could:

- Improve access to banking and financial services, particularly in rural and underserved areas, to make it easier for remittance recipients to invest funds productively.
- Encourage the use of digital financial platforms to reduce transaction costs and increase transparency in remittance flows.

2. Incentivizing Productive Use of Remittances: Policymakers could implement incentive programs to encourage recipients to invest remittances in productive sectors, such as entrepreneurship, real estate, and local business ventures. This could include:

- Offering tax incentives or matching funds for remittance recipients who invest in certain sectors.
- Promoting financial literacy programs to educate remittance recipients about investment opportunities and the long-term benefits of saving and investing.

3. Fostering Public-Private Partnerships: The positive impact of remittances on economic growth could be maximized through public-private partnerships (PPPs) aimed at channeling remittances into infrastructure and social projects. Governments could:

- Partner with financial institutions and private firms to create specialized remittance investment funds or bonds that direct remittances toward infrastructure development or other public goods.
- Collaborate with diaspora organizations to mobilize remittances for specific national development goals, such as affordable housing or sustainable agriculture.

4. Aligning National Development Strategies with Remittances: Remittances play a vital role in the economies of North African countries, yet their potential remains underutilized. Policymakers should align remittance-related policies with broader national development strategies by:

- Incorporating remittance flows into macroeconomic planning and poverty reduction strategies.
- Establishing clear regulatory frameworks to manage remittance inflows efficiently and ensure they contribute to long-term national goals such as education, healthcare, and infrastructure development.

5. Addressing Informal Remittance Channels: The study highlights the use of informal remittance channels in some countries, which reduces the potential benefits of these funds for the formal economy. A governance policy could focus on:

- Creating more attractive and efficient formal channels by reducing fees, enhancing accessibility, and providing faster services.
- Collaborating with international organizations to curb the use of informal remittance systems and increase the overall security of money transfers.

By implementing these governance policies, North African countries can more effectively harness remittances to boost economic growth, reduce poverty, and promote sustainable development.

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