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Renewable Energy, Green Finance, and Economic Growth in Morocco: Evidence from an ARDL Approach

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ABSTRACT

This paper investigates the relationship between green finance, renewable energy, and economic growth in Morocco, highlighting their roles in achieving sustainable development objectives. Morocco's proactive approach, marked by the issuance of green bonds and the formulation of a national green taxonomy, aligns with global commitments to the Paris agreement and the Sustainable Development Goals. The study adopts the auto-regressive distributed Lag (ARDL) model to analyze quarterly data from 2016 to 2022, incorporating key variables such as green finance, foreign direct investment (FDI), renewable energy consumption, and greenhouse gas (GHG) emissions. The empirical findings indicate that while a 1% increase in green finance results in a modest 0.01% rise in GDP, renewable energy consumption demonstrates stronger short-term (0.29%) and long-term (0.36%) contributions to economic growth. Conversely, GHG emissions show a positive correlation with GDP, underscoring the ongoing reliance on carbon-intensive sectors despite efforts to transition to a green economy. The results emphasize the importance of robust regulatory frameworks, technological innovation, and public-private partnerships in maximizing the benefits of green finance and renewable energy investments. Addressing institutional barriers, improving market transparency, and fostering investor confidence through mechanisms such as green bonds and digital finance tools are critical to accelerating Morocco's transition to a low-carbon economy. This study provides valuable insights for policymakers and stakeholders seeking to harmonize economic growth with environmental sustainability.

Keywords: Sustainable Development, Renewable Energy, Energy Transition, Sustainable Finance, Green Economy
JEL Classifications: Q01, Q42, Q43, G38, Q56

1. INTRODUCTION

In recent years, Morocco has shown strong dedication to integrating sustainable practices into its economic framework, particularly in green finance and renewable energy. While the development of a national green taxonomy is underway with World Bank support, this initiative seeks to guide investments toward sustainable activities and reduce greenwashing risks (World Bank, 2021). Notable achievements include MASEN's green bond issuance in 2016, which raised 1.15 billion MAD to co-finance the Noor PV1 solar project. This was followed by similar green bonds from BMCE Bank, Banque Centrale Populaire (BCP) and Casablanca Finance City, reflecting Morocco's commitment to financing environmentally impactful projects (Bennis, 2023).

These efforts are part of a broader strategy to align economic development with the United Nations sustainable development goals (SDGs) and the Paris Agreement on climate change (UNEP, 2022). However, like many emerging economies, Morocco faces the dual challenge of achieving robust economic growth while limiting its environmental footprint. In this context, green finance plays a pivotal role by mobilizing resources for sustainable

infrastructure, energy efficiency, and clean technologies. While its direct impact on GDP remains modest in the short term, its long-term benefits, particularly in fostering innovation and systemic transitions, are promising (Flammer, 2021; OECD, 2023).

Moreover, Morocco's significant investments in renewable energy reflect a strategic vision to reduce its reliance on fossil fuels and enhance energy security. The Noor Ouarzazate solar complex, one of the world's largest concentrated solar power projects, alongside the Tarfaya Wind Farm, are flagship projects that position Morocco as a regional leader in renewable energy (Bouyghrissi et al., 2020). These initiatives also support the country's goal of achieving 52% of its energy mix from renewable sources by 2030, aligning with global trends linking renewable energy consumption, reduced CO_2 emissions, and economic growth (IRENA, 2022).

On an institutional level, the Moroccan government has introduced reforms to attract greater investment in green sectors. The adoption of the National Strategy for Sustainable Development (NSDS) and other initiatives, such as the Green Generation 2020-2030 Plan, reflect an integrated approach that combines green finance, renewable energy, and socio-economic objectives (HCP, 2022). These policies address critical issues such as unemployment, rural development, and energy access while positioning Morocco as a regional model for financial and energy transitions (AfDB, 2023; UNDP, 2024).

This study aims to analyze the complex relationship between green finance, renewable energy, and economic growth in Morocco. Through a literature review, a rigorous methodological approach, and an analysis of results, it provides insights into policy implications and actionable strategies to accelerate the transition to a sustainable and low-carbon economy.

2. LITERATURE REVIEW

Green finance is a relatively recent concept that has emerged as an innovative response to global environmental challenges. According to Wang et al. (2019), it represents a new category of financial instruments specifically designed to support projects and initiatives with a positive environmental impact. These instruments share the fundamental characteristics of traditional finance but are distinct in that they explicitly aim to promote environmental sustainability. Wang and Zhi (2016) highlight two key levers: The creation of markets for green financial products, such as green bonds, and the establishment of fiscal policies that incentivize green investments. These mechanisms are crucial for mobilizing substantial funds toward ecological projects and supporting a sustainable transition.

In recent years, the scope of green finance has broadened to include diverse instruments such as green bonds, carbon markets, and climate-focused funds. The increasing adoption of these tools by both public and private entities highlights their potential to accelerate the transition toward low-carbon economies (Flammer, 2021). Furthermore, institutions such as the International Finance Corporation (IFC) and the green climate fund (GCF) have been instrumental in promoting green finance in emerging markets by providing technical and financial support to sustainability-oriented projects (Nguyen et al., 2023). Nakhooda et al. (2014) emphasize the success factors of multilateral climate funds, such as transparent governance and clearly defined targets. These elements could inspire the strengthening of local initiatives in Morocco, particularly in implementing its national green finance strategy.

The growing interest in green finance stems from the recognition that financial development and economic growth must align with environmental sustainability goals. In this context, green finance stimulates economic growth while addressing ecological imperatives. Previous research supports this perspective, demonstrating the positive role of financial development in promoting economic growth across developed, emerging, and developing economies (King and Levine, 1993; Demetriades and Hussein, 1996; Beck et al., 2000; Nieuwerburgh et al., 2006; Bittencourt, 2012).

Furthermore, evidence shows that green finance fosters sustainable industrial transformation. For example, Uddin and Zakir (2013) observed that green financing mechanisms effectively channel resources toward renewable energy and clean technologies in Asia, promoting energy diversification and reducing carbon footprints. Marques and Fuinhas (2013) highlighted that aligning capital flows with environmental goals strengthens the resilience of financial systems and mitigates risks associated with environmental shocks.

Despite its potential, green finance remains a relatively underexplored area in academic literature, partly due to its recent emergence. Nevertheless, some studies have begun to examine its impact on economic and environmental development. Yen and Xu (2022), for example, identified a double threshold effect of green investment in renewable resources on green economy development. Their results suggest that, in the long term, green investments in renewable energy can effectively stimulate the growth of the green economy.

In addition, research by Chen et al. (2023) highlights the role of digital technologies such as blockchain in improving the transparency and traceability of green finance mechanisms. Their findings suggest that integrating such technologies into green finance frameworks can enhance investor confidence and accountability, thus mobilizing greater capital for environmental projects.

Similarly, Pradhan et al. (2018) explored the relationship between energy consumption, financial development, and economic growth in the financial action task force (FATF) member countries. Their study advocates for increased government support for investment in green finance, particularly in clean energy areas such as natural gas. They argue that such investments can simultaneously contribute to environmental protection and economic growth.

Findings from recent studies on Morocco provide valuable insights into the role of green finance in sustainable development. For example, evidence from empirical analysis suggests that greenhouse gas (GHG) emissions are a significant driver of renewable energy investments in Morocco, indicating the country's

strategic reliance on renewable energy to combat climate change and reduce its carbon footprint (Nabil et al., 2024). The analysis also highlights a positive but indirect relationship between green finance and economic growth, suggesting that the green finance ecosystem in Morocco remains underdeveloped due to data limitations and the early stage of implementation. Despite these constraints, green finance has demonstrated its potential to stabilize emissions while supporting investments in renewable energy, reinforcing its role as a catalyst for sustainable development (Nabil et al., 2024).

After the 2008 financial crisis, financial markets experienced increased volatility and uncertainty (Neaime, 2012; Assaf, 2016). In this context, the question of the relationship between financial development and economic growth took on a new dimension. Increasingly, studies have highlighted that excessive financial development could hinder economic growth (Hye and Islam, 2013; Ibrahim and Alagidede, 2018). This perspective challenges the traditional notion that financial development is always beneficial for economic growth.

The development of green finance adds a layer of complexity to this debate. If traditional financial development can have ambiguous effects on economic growth, it is relevant to question whether green finance, with its specific focus on sustainability and environmental responsibility, can offer a different and potentially more positive path. Wang and Zhang (2021) argue that green finance could help mitigate systemic risks by promoting long-term investments in climate-resilient infrastructure and industries.

This question becomes particularly relevant in the post-financial crisis context, where increased instability characterizes financial markets. Green finance focuses on sustainable and long-term investments, offering a pathway to more stable and resilient economic growth. Furthermore, as global environmental challenges like climate change intensify, green finance plays a crucial role in funding the transition to a greener and more sustainable economy.

Wang et al. (2022) contribute significantly to understanding the dynamics between green finance (GF) and sustainable development (SD). Their study applies the bootstrap rolling window Granger causality test to comprehensively assess the causal relationship between these concepts over different periods. This methodological approach captures temporal variations in the causal relationship, providing a more nuanced and dynamic perspective on the interaction between green finance and sustainable development.

The results of the empirical analysis reveal that green finance has positive impacts on sustainable development in various sub-periods. This suggests that investments and initiatives in the field of green finance can significantly contribute to achieving sustainable development goals. These positive impacts can manifest in various ways, such as reducing greenhouse gas emissions, promoting energy efficiency, or supporting environmentally friendly projects.

Furthermore, Flammer (2021) demonstrated that green bonds not only help finance renewable energy projects but also enhance the environmental credibility of their issuers. This dual benefit has made green bonds one of the fastest-growing instruments in global financial markets.

3. MATERIALS AND METHODS

This study examines the relationship between green finance and economic growth in Morocco by incorporating three additional variables: renewable energy, foreign direct investment (FDI), and greenhouse gas (GHG) emissions. Researchers express the proposed model as follows:

$$GDP_t = \lambda_\circ + \delta_1 GF_t + \delta_2 REC_t + \delta_3 FDI_t + \delta_4 GHC_t + Et \quad (1)$$

Where:

- GDP: Gross domestic product
- GF: Green finance
- REC: Renewable energy consumption
- FDI: Foreign direct investment
- GHC: Greenhouse Gas
- Et: Error term

Researchers express all variables in natural logarithms to address issues with non-normality and to interpret the coefficients as elasticities (Paramati et al., 2016; Ummalla and Samal, 2019). The logarithmic transformation also ensures that the data better meets the assumptions of a linear regression model, as shown in the following equation:

- The expected value of the error terms is zero, meaning they are not systematically underestimated or overestimated
- The variance of the error terms is constant (homoscedasticity) and finite
- The error terms are uncorrelated with each other
- The error terms are independent of the explanatory variables
- The error terms are normally distributed, essential for hypothesis testing and confidence interval construction.

The analysis uses annual data from 2016 to 2022, a period critical to Morocco's progress in green finance. This timeframe highlights key developments, including the National Strategy for Sustainable Development, which aligns with the United Nations Sustainable Development Goals and the Paris Agreement. It also marks the country's first green bond issuances and intensified efforts to reduce carbon emissions and promote renewable energy. The study segments the data into four quartiles to provide a detailed analysis of trends and variations. Researchers conducted a thorough data collection process to compile green finance-specific information for Morocco, addressing the challenge of fragmented and limited sources. They also cross-referenced data on green emissions from the Climate Bond Initiative for the African continent and aggregated all international and national support programs specific to Morocco.

The study collected data from the World Bank, the National Environmental Information System, the energy information administration (EIA), and the climate bond initiative (CBI). Researchers apply the ARDL (Auto-Regressive Distributed Lag) approach to estimate short- and long-term relationships between the variables (Table 1).

To estimate the coefficients of the ARDL model, researchers transform equation (1) as follows:

$$\begin{aligned}\Delta lGDP_t &= \lambda_\infty + \sum_{i=1}^{p}\delta_{1\,j}\Delta lGDP_{t-k} + \sum_{i=1}^{p}\delta_{2\,j}\Delta lGF_{t-k} \\ &+ \sum_{i=1}^{p}\delta_{3\,j}\Delta lREC_{t-k} + \sum_{i=1}^{p}\delta_{4\,j}\Delta lFDI_{t-k} + \\ &\sum_{i=1}^{p}\delta_{5\,j}\Delta\ lGHC_{t-k} + \psi_1 lnGDP_{t-1} + \psi_2 lGF_{t-1} + \\ &\psi_3 lREC_{t-1}\psi_4\, lFDI_{t-1} + \psi_5\, lGHC_{t-1} + Et \end{aligned} \quad (2)$$

With:

- LGDP: The natural logarithm of GDP;
- LFV: The natural logarithm of the green finance variable;
- LREC: The natural logarithm of renewable energies;
- LFDI: The natural logarithm of foreign direct investments (FDI);
- LGHC: The natural logarithm of greenhouse gas emissions (GHG);
- Δ: The first difference operator;
- Et: The error term.

Moreover, the null hypothesis of no cointegration in equation (2) states that (H_0: $\psi_1 = \psi_2 = \psi_3 = \psi_4 = \psi_5 = 0$), against the alternative hypothesis H_1 (H_1: $\psi_1 \neq \psi_2 \neq \psi_3 \neq \psi_4 \neq \psi_5 \neq 0$)

If the calculated F-statistic value falls below the critical bounds at the 10%, 5%, and 1% significance levels, researchers accept the null hypothesis (H_0), indicating no cointegration relationship among the variables. However, if the F-statistic exceeds the upper critical bound, they reject the null hypothesis, confirming the presence of a long-term cointegration relationship between the variables. If the F-statistic lies between the lower and upper bounds, researchers classify the cointegration test as inconclusive.

After establishing the long-term relationship using the ARDL model, researchers estimate the error correction model (ECM) as follows:

$$\begin{aligned}\Delta lGDP_t &= \lambda_\infty + \delta_1 \sum_{i=1}^{p}\delta_{1\,j}\Delta lGDP_{t-1} + \sum_{i=1}^{p}\delta_{2\,j}\Delta lGF_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3\,j}\Delta lREC_{t-1} + \sum_{i=1}^{p}\delta_{4\,j}\Delta lFDI_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5\,j}\Delta lGHC_{t-1} + \psi ECT_{t-1} + Et \end{aligned} \quad (3)$$

With Δ, the first difference operator, and ECT t_{-1}, the error correction term derived from the long-term equilibrium relationship.

To analyze the long-term causal relationship between Gross domestic product (GDP), green finance, emissions, foreign direct investments, and renewable energies, researchers first test for the existence of a cointegration relationship among these variables. Once they establish this relationship, they apply the vector error correction model (VECM) to examine the Granger causality link between these variables.

To achieve this, the researchers estimate the following model:

$$\begin{aligned}\Delta lGDP_t &= \delta_0 + \sum_{i=1}^{p}\delta_{1i}\Delta lGDP_{t-1} + \sum_{i=1}^{p}\delta_{2i}\Delta lGF_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3i}\Delta lREC_{t-1} + \sum_{i=1}^{p}\delta_{4i\,j}\Delta lREC_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5i\,j}\Delta\ lGHC_{t-1} + \psi_1 ECT_{t-1} + Et \end{aligned} \quad (5)$$

$$\begin{aligned}\Delta lGF_t &= \delta_0 + \sum_{i=1}^{p}\delta_{1i}\Delta lGF_{t-1} + \sum_{i=1}^{p}\delta_{2i}\Delta lGDP_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3i}\Delta lREC_{t-1} + \sum_{i=1}^{p}\delta_{4i\,j}\Delta\ lFDI_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5i\,j}\Delta\ lGHC_{t-1} + \psi_2 ECT_{t-1} + Et \end{aligned} \quad (6)$$

$$\begin{aligned}\Delta lREC_t &= \delta_0 + \sum_{i=1}^{p}\delta_{1i}\Delta lREC_{t-1} + \sum_{i=1}^{p}\delta_{2i}\Delta lGDP_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3i}\Delta lGF_{t-1} + \sum_{i=1}^{p}\delta_{4i\,j}\Delta\ lFDI_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5i\,j}\Delta\ lGHC_{t-1} + \psi_3 ECT_{t-1} + Et \end{aligned} \quad (7)$$

$$\begin{aligned}\Delta lFDI_t &= \delta_0 + \sum_{i=1}^{p}\delta_{1i\,j}\Delta\ lFDI_{t-1} + \sum_{i=1}^{p}\delta_{2i}\Delta lGDP_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3i}\Delta lGF_{t-1} + \sum_{i=1}^{p}\delta_{4i}\Delta lREC_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5i\,j}\Delta\ lGHC_{t-1} + \psi_4 ECT_{t-1} + Et \end{aligned} \quad (8)$$

$$\begin{aligned}\Delta lGHC_t &= \delta_0 + \sum_{i=1}^{p}\delta_{1i\,j}\Delta\ lGHC_{t-1} \sum_{i=1}^{p}\delta_{2i}\Delta lGDP_{t-1} + \\ &\sum_{i=1}^{p}\delta_{3i}\Delta lGF_{t-1} + \sum_{i=1}^{p}\delta_{4i}\Delta lREC_{t-1} + \\ &\sum_{i=1}^{p}\delta_{5i\,j}\Delta\ lFDI_{t-1} + \psi_5 ECT_{t-1} + Et \end{aligned} \quad (9)$$

4. RESULTS

4.1. ARDL Cointegration Tests

The results of the augmented dickey-fuller (ADF) and Phillips-Perron (P-P) tests presented in the table clearly indicate the stationary behavior of the economic variables after logarithmic transformation, both at the level and in the first difference (Table 2).

For the GDP series, the ADF at the level shows a t-statistic of −1.682911 with a P = 0.7273, which is not sufficient to reject the null hypothesis of non-stationarity. However, in the first difference, the ADF shows a t-statistic of −3.971188 and a P = 0.0251, allowing us to reject the null hypothesis, indicating that the series is stationary after the first difference.

Similarly, for GF, the ADF at the level gives a t-statistic of −3.211907 with a P = 0.1057, while in the first difference; the t-statistic is −5.423384 with a P = 0.0012, confirming stationarity after differentiation. The REC and FDI series follow the same pattern. At the level, the ADF tests fail to reject the null hypothesis of non-stationarity with P = 0.3920 and 0.3280, respectively. Nevertheless, the ADF tests in the first difference for REC and FDI show P-values well below the 0.05 threshold, suggesting that the first differences of these series are stationary (Table 3).

The study highlights the significant but modest impact of green finance on Morocco's economy, where a 1% increase in green bonds results in a 0.01% rise in GDP. This underscores Morocco's commitment to sustainable and environmentally friendly investments, reflecting a gradual transition towards a greener economy aligned with sustainable development goals. Additionally, foreign direct investments (FDI) play a crucial role in economic growth, with a 1% increase in FDI associated with a 0.057% rise in GDP, as they bring essential capital, technology, and skills that enhance productivity and economic development (Tables 4 and 5).

Despite the environmental concerns, greenhouse gas (GHG) emissions show a positive correlation with GDP, indicating that emission-heavy industries remain key contributors to Morocco's economic growth, with a 1% increase in GHG emissions leading to a 1.11% rise in GDP. Renewable energy also significantly drive economic growth, with a 1% increase in renewable energy consumption resulting in a 0.29% GDP rise. This emphasizes the importance of Morocco's substantial investments in renewable energy sources, such as the Noor Ouarzazate solar power plant, one of the largest in the world.

The long-term analysis indicates that the impact of green finance on Morocco's economy is not statistically significant at the 5% threshold. However, foreign direct investments (FDI) and total greenhouse gas (GHG) emissions have significant effects on GDP at this threshold, highlighting their important role in the country's economic growth. Renewable energy also show a significant influence on GDP at the 10% threshold, demonstrating their growing contribution to the national economy (Table 6).

Table 1: Variable descriptions

Variables	Measurement	Abbreviations	Sources
Gross domestic product	Annual growth rate of national GDP	GDP	WDI
Foreign direct investment	Contribution of FDI to GDP	FDI	CEIC
Green finance	Total annual green finance in Morocco	GF	CBI
Renewable energy	Percentage of renewable energy in total energy consumption	REC	IEA-MTEDD
Emissions	Greenhouse gas emissions	GHC	NDC-MTEDD

CBI: Climate bond initiative, ARDL: Auto-regressive distributed lag, GDP: Gross domestic product, REC: Renewable energy consumption, GF: Green finance, FDI: Foreign direct investment

Table 2: Stationarity test

Variables	ADF at level		ADF 1st difference		P-P at level		P-P 1st difference	
	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value
GDP	−1.682911	0.7273	−3.971188	0.0251	−1.773588	0.6856	−3.971188	0.0251
GF	−3.211907	0.1057	−5.423384	0.0012	−3.201210	0.1078	−6.351363	0.0002
REC	−2.353862	0.3920	−5.982178	0.0003	−2.245288	0.4454	−6.181003	0.0002
FDI	−2.43290	0.3280	−5.322709	0.0014	−2.545614	0.3056	−5.658121	0.0007
GHC	−2.257871	0.1927	−5.613693	0.0001	−2.257871	0.1927	−5.814401	0.0001

Source: Author's calculation

CBI: Climate bond initiative, ARDL: Auto-regressive distributed lag, GDP: Gross domestic product, REC: Renewable energy consumption, GF: Green finance, FDI: Foreign direct investment

Table 3: Optimal lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	93.45896	NA	3.02e−05	−8.15689	−8.10256	−8.145236
1	142.25638	94.12457*	4.48e−10	−12.48569	−11.36987*	−12.35694
2	168.27956	21.89445	4.36e−10*	−12.71498	−10.95487	−12.45896
3	191.24563	15.02544	5.02e−10	−12.9124*	−10.41236	−12.5025*

Source: Author's calculation

These results strongly suggest that there is cointegration among the studied variables, implying that they move together over the long term and that any short-term divergence between them would be temporary, adjusting over time to maintain a stable equilibrium relationship. This indicates a long-term interconnectedness where variables such as green finance, FDI, GHG emissions, and renewable energy consumption collectively influence Morocco's economic development.

4.2. Causality and Parameter Stability

The results indicate that in Morocco, there is a unidirectional causality from GDP to total greenhouse gas (GHG) emissions at a 5% significance level, meaning that changes in GDP lead to changes in CO_2 emissions, but not the reverse (Table 7). This aligns with previous studies by Bouyghrissi et al. (2020), and Nabil et al. (2023). Additionally, a unidirectional causality from renewable energy consumption to GDP suggests that reducing renewable energy use would have minimal impact on economic growth, supporting findings by Rahman and Velayutham (2020).

An intriguing finding reveals a unidirectional causality from GHG emissions to renewable energy development, showing that increasing emissions drive investments in renewables. This aligns with Morocco's strategy of leveraging renewable energy to combat climate change and reduce its carbon footprint. These results emphasize the significant role of economic growth in influencing CO_2 emissions and demonstrate that transitioning to renewable energy can occur without impeding economic growth. The lack of a causal link between green finance and economic growth likely stems from data limitations or the early stage of green finance development in Morocco.

Figure 1 present the results of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares (CUSUM-squared) tests. Both diagrams fall within the critical bounds at the 5% significance level, confirming the stability of the ARDL parameters in this study.

Table 4: Results of the CT coefficients

Variable	Coefficient	Standard error	t-statistics	Prob.
D (FDI)	0.057162	0.008317	6.872791	0.0000
D (GHC)	1.111559	0.069196	16.06396	0.0000
D (GF)	0.016925	0.004100	4.128371	0.0007
D (REC)	0.290904	0.092866	3.132506	0.0061
CointEq(−1)*	−0.352644	0.130646	−2.69922	0.0152
R-SQuared				0.958089
Adjusted R-square				0.950469

Source: Author's calculation
CT: Computed tomography, REC: Renewable energy consumption, GF: Green finance, FDI: Foreign direct investment

Table 5: Results of the LT coefficients

Variable	Coefficient	Standard error	t-statistics	Prob.
FDI	0.054491	0.026111	2.521454	0.0220
GHC	1.057762	0.095733	11.04913	0.0000
GF	0.011694	0.009423	1.240972	0.2315
REC	0.368933	0.187140	1.971432	0.0652
C	3.959140	2.165853	1.827982	0.0852

Source: Author's calculation
REC: Renewable energy consumption, GF: Green finance, FDI: Foreign direct investment

Table 6: Bound test results

Statistical tests	Value	Signif. (%)	I (0)	I (1)
F-statistic	4.938327	10	2.2	3.09
K	4	5	2.56	3.49
		2.5	2.88	3.87
		1	3.29	4.37

Source: Author's calculation

5. DISCUSSION AND POLICY IMPLICATIONS

Green finance in Morocco has emerged as a strategic tool for aligning financial investments with environmental sustainability objectives. Initiatives such as the development of a national green taxonomy, supported by the World Bank, provide clear guidelines for identifying sustainable economic activities and assets. This taxonomy mitigates the risks of greenwashing while directing investments toward projects with significant environmental benefits. Morocco has also led the issuance of green bonds, starting with MASEN in 2016, which raised 1.15 billion MAD to co-finance the Noor PV1 solar project. Subsequent issuances by BMCE Bank, Banque Centrale Populaire (BCP), and Casablanca Finance City have further mobilized funds for sustainable projects. These initiatives reflect Morocco's commitment to establishing a robust green finance ecosystem that supports its transition to a low-carbon economy.

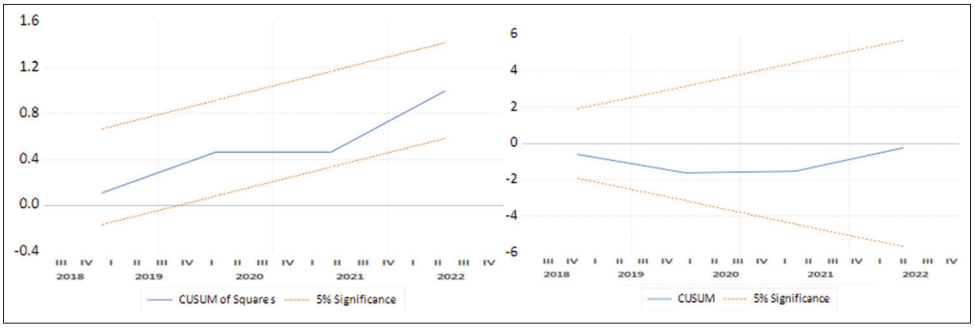
The study highlights the significant but modest impact of green finance on Morocco's short-term economic growth, with a 1% increase in green bonds contributing to a 0.01% rise in GDP. However, the long-term effects remain statistically insignificant, indicating that green finance is still in its infancy within Morocco's economic structure. Nonetheless, their impact extends beyond immediate economic figures. Flammer (2021) demonstrates that

Table 7: Granger causality test

	ΔGDP	ΔFDI	ΔGHC	ΔGF	ΔREC
ΔGDP	–	1.270663 (0.235)	6.715113 (0.457)	1.022159 (0.334)	3.165245* (0.003)
ΔFDI	12.18154 (0.564)	–	0.125621 (0.688)	0.011435 (0.455)	0.505215 (0.9568)
ΔGHC	6.04628** (0.035)	1.628022 (0.618)	–	1.265438 (0.568)	3.167462 (0.8491)
ΔGF	1.153667 (0.264)	1.855432 (0.227)	0.524372 (0.540)	–	3.165245 (0.503)
ΔREC	0.668285 (0.4789)	0.273123 (0.656)	4.543455** (0.041)	3.151121 (0.702)	–

Source: Author's calculation

Figure 1: Stability test CUSUM and CUSUM of suqares



Source: Author's calculation

green bonds, in addition to financing sustainable projects, enhance the environmental credibility of issuers, thereby increasing their attractiveness to investors and broadening funding opportunities.

Factors such as challenges in accessing green financing, limited awareness of green financial products among economic actors, and institutional obstacles impede its full integration. To address these challenges, Morocco has implemented regulatory measures, including a green bonds guide and directives from Bank Al-Maghrib, to ensure that funds raised are directed toward environmentally beneficial projects. These efforts, coupled with capacity-building and public-private partnerships, aim to enhance the long-term impact of green finance on economic growth. Another promising avenue is the integration of digital technologies into green finance. Chen et al. (2023) illustrate that tools like blockchain can improve transparency and traceability of green financial flows, bolstering investor confidence and mobilizing additional capital for sustainable projects.

Renewable energy investments have shown substantial contributions to Morocco's economic growth, both in the short and long term. A 1% increase in renewable energy consumption leads to a 0.29% rise in GDP in the short term and a 0.36% increase in the long term, demonstrating their potential as key drivers of sustainable growth. Flagship projects like the Noor Ouarzazate solar complex and the Tarfaya Wind Farm have strengthened Morocco's energy security and reduced its dependence on fossil fuel imports. However, integrating renewable energy into the national grid remains a challenge, particularly regarding grid stability and energy storage. Laws such as Law 13-09 and Law 58-15 have encouraged private sector participation and facilitated the injection of renewable energy into the grid, addressing some of these challenges. Additionally, the recent exemption of import duties on photovoltaic panels and initiatives to develop local production capacity for solar technology are pivotal for fostering innovation and reducing dependency on imported technologies.

Foreign direct investment (FDI) and greenhouse gas (GHG) emissions also significantly influence Morocco's economic growth. A 1% increase in FDI contributes to a 0.057% rise in GDP, highlighting the importance of foreign capital in driving productivity and technological advancements. However, a 1% rise in GHG emissions results in a 1.11% increase in GDP, indicating the ongoing reliance on carbon-intensive sectors for economic output. While this relationship underscores the need for immediate economic diversification, it also highlights the challenges Morocco faces in transitioning toward a low-carbon economy. Policies such as the National Climate Plan and preparations for the European Union's Carbon Border Adjustment Mechanism (CBAM) are critical for mitigating the risks of carbon dependency and promoting a green transition across industrial sectors.

The integration of renewable energy into the energy mix has proven to be an effective strategy for reducing the country's reliance on imported fossil fuels, achieving energy security, and enhancing economic resilience. The target of generating 52% of the energy mix from renewable sources by 2030 has positioned Morocco as a regional leader in the MENA region. However, the realization of this target requires significant investment in grid modernization, energy storage technologies, and regulatory frameworks. Furthermore, the development of local production chains for renewable energy components, such as photovoltaic panels, offers an opportunity to stimulate job creation and technological innovation while reducing import dependency.

Morocco's broader efforts to transition to a green economy are supported by strategic regulatory and policy measures, including the implementation of the National Sustainable Development Strategy (NSDS-2030), the Low-Carbon Development Strategy, and sectoral initiatives such as the Morocco Climate Business Initiative. These frameworks not only align with international sustainability goals but also reflect Morocco's ambition to establish itself as a global leader in green finance and renewable energy. Despite the challenges, Morocco's proactive stance in preparing for mechanisms like the CBAM demonstrates its readiness to leverage international regulatory changes as opportunities for economic growth and competitiveness. These combined efforts underscore the country's potential to achieve balanced and sustainable economic development in the years to come.

Institutional efforts, such as the implementation of the Bank Al-Maghrib directive on green bonds and the exemption of import duties on photovoltaic panels, demonstrate a commitment to accelerating the country's energy and financial transition. Additionally, the development of local production chains for renewable energy technologies could strengthen the economy's resilience to international price fluctuations and create opportunities to stimulate innovation and employment. These initiatives, combined with a clear decarbonization strategy and increased international cooperation, are likely to maximize

the economic and environmental impacts of Morocco's green policies.

6. CONCLUSION

The transition toward a sustainable economy in Morocco exemplifies an integrated approach that leverages green finance and renewable energy as pillars of sustainable development (Ainou et al., 2022, Bouyghrissi &al 2023). Initiatives such as the publication of a national green taxonomy, the issuance of green bonds, and the deployment of flagship projects like the Noor Ouarzazate solar power complex reflect a strategic commitment to reducing reliance on fossil fuels while aligning national policies with the Sustainable Development Goals (SDGs) and the Paris Agreement.

The outcomes of this transition demonstrate significant long-term potential. Green finance, although still in its nascent stages, has emerged as a critical tool for channeling financial resources toward projects with substantial environmental and social impact. However, its direct contribution to economic growth remains modest in the short term, largely due to limited integration within economic systems and persistent institutional barriers. Meanwhile, renewable energy—particularly solar and wind—has positioned itself as a structural driver of growth, enhancing energy security and diversifying the economy.

This analysis also highlights the challenges inherent in Morocco's energy transition and green finance initiatives. These include the complexity of regulatory frameworks, the high initial costs of green technologies, and barriers to integrating investments into sustainable infrastructure. Moreover, the observed positive correlation between greenhouse gas emissions and economic growth underscores the structural dependence on carbon-intensive sectors, emphasizing the need for profound economic transformations.

To address these challenges, it is imperative to strengthen regulatory frameworks, enhance investor awareness, and foster inclusive governance mechanisms. The adoption of technologies such as blockchain to increase transparency and traceability in green financial flows could also play a catalytic role. Additionally, scaling up public-private partnerships and implementing targeted financial incentives are critical for mobilizing additional resources and accelerating the transition.

In conclusion, Morocco positions itself as a promising model for emerging economies seeking to reconcile economic development with environmental sustainability. However, the success of this model depends on robust cross-sectoral coordination, enhanced institutional commitment, and improved attractiveness for green financing. These dynamics are essential to ensuring a smooth transition toward a resilient economy that meets global environmental demands while supporting inclusive and sustainable growth.

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