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Renewable Energy, Carbon Emissions, and Current-Account Dynamics in Morocco: Evidence from a VECM Approach

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Abstract

This paper examines the relationship between renewable energy consumption, industrial-process CO_2 emissions, economic complexity, and Morocco's current-account balance over the period 2001–2022, and relates the current account to renewable energy consumption, industrial-process CO_2 emissions, and economic complexity. The results indicate that the variables are cointegrated, which supports the estimation of a VECM. The main long-run result is that industrial-process CO_2 emissions are negatively associated with the current account. Renewable energy consumption and economic complexity, however, do not show statistically significant effects in the estimated model. The short-run results also provide no clear evidence that changes in these variables explain movements in the current account. These findings suggest that Morocco's external balance is still more closely linked to carbon-intensive production than to the benefits expected from renewable-energy consumption. The results also imply that renewable energy may contribute more to the current account only when the transition becomes less dependent on imported equipment, technology, and intermediate inputs.

Keywords: Renewable energy; Current account; CO_2 emissions; Economic complexity; Morocco, VECM.
Jel codes: Q43, F32

1. Introduction

Energy is a fundamental input for modern economic activity because it supports production, transportation, trade, household consumption, and industrial development. Rising energy demand, fossil-fuel price volatility, and geopolitical disruptions have increased the need for reliable and sustainable energy sources. Recent shocks, including the Russia–Ukraine war, have renewed attention to energy security and accelerated the policy shift toward renewable-energy transition (Atems &Hotaling, 2018; Zhang et al., 2023; International Energy Agency, 2024).

The case of Morocco presents an important opportunity for studying the possible impacts of the renewable transition on the external sector. Unlike hydrocarbon-producing countries in the region, Morocco has limited fossil-fuel resources and is heavily dependent on imported petroleum and other energy products to meet domestic demands (U.S. Energy Information Administration, 2019). Due to this dependence, the economy is exposed to changes in international energy prices, and there is pressure on both the trade balance and the current account. In response, Morocco has increased its renewable-energy production through national policy initiatives,

international financing, and major projects, such as Noor Ouarzazate and Noor Midelt (El Gharras &Menichetti, 2018; Kousksou et al., 2015).

Morocco's current account is affected not only by energy imports but also by tourism revenues, remittances, agricultural performance, export structure, and worldwide economic conditions. This makes Morocco a useful case for examining whether renewable energy can contribute to external-balance improvement by reducing fossil-fuel import dependence. At the same time, economic complexity may influence the current account through export sophistication and productive upgrading, while carbon emissions may reflect continued reliance on fossil-fuelbased activity.

Renewable energy, CO2 emissions, economic complexity, and the current account are all related through channels of open economies and structural transformations. Open-economy theory holds that the current account reflects the dynamics of saving and investment as well as the balance between exports and imports (Obstfeld &Rogoff, 1995; Thirlwall, 1979). A fossil-fuel-dependent economy may be exposed to oil price shocks and terms-of-trade shocks, which could adversely affect its current account (Backus &Crucini, 2000). The use of renewable energy can reduce external pressure by reducing fossil-fuel import dependence, though this effect may be delayed if the transition requires the import of equipment and technology. While economic complexity may increase export sophistication, structural upgrading may also result in an increase in imported capital goods and intermediate inputs (Hidalgo et al., 2007; Hidalgo &Hausmann, 2009).

The central research question in this study is whether renewable energy consumption and economic complexity can improve Morocco's current-account position while reducing dependence on carbon-intensive industrial activity. The study adds to the literature by linking renewable-energy transition, industrial-process CO_2 emissions, and economic complexity to external-balance performance in a fossil-fuel-importing MENA economy.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data and empirical methodology. Section 4 presents and discusses the empirical findings. Section 5 concludes.

2. A Review of the Literature

The link between renewable energy and the current account has received increasing attention in the energy-economics literature. Bousnina and Gabsi (2023) examined how renewable energy and CO_2 emissions affect the current-account balance in OECD countries. Their findings indicate that renewable energy has a significant positive effect on the current account only in the long run, whereas CO_2 emissions negatively affect the current account in both the short run and the long run. This result is also in line with Juhro et al. (2024), who showed that the transition toward a green economy may benefit net oil-importing countries once renewable energy consumption passes a certain threshold.

Similarly, Ozkan and Okay (2024) studied the relationship between renewable energy, net energy imports, and current-account deficits in OECD countries. Their results indicate that net energy imports increase current-account deficits, while renewable energy supports currentaccount performance over the long run. These findings imply that renewable energy may influence the current account through the import-substitution channel, particularly in economies that rely heavily on imported fossil fuels.

This argument is relevant for Morocco because the country relies heavily on imported energy. Renewable energy may therefore help reduce fossil-fuel import dependence and improve the current account. However, this effect may not appear immediately because renewable-energy projects often require imported equipment, technology, and infrastructure. Therefore, the impact of renewable energy on the current account may be stronger in the long-run than in the short-run.

Several studies have examined Morocco's transition to renewable energy. According to Kousksou et al. (2015), renewable energy can support sustainable development and reduce reliance on fossil fuels. El Gharras and Menichetti (2018) discussed Morocco's efforts to become a regional leader in sustainable energy through large-scale projects and international collaboration. In addition, Chentouf and Allouch (2021) stressed the importance of renewable energy for strengthening Morocco's energy security and supporting its long-term energy strategy.

Economic complexity (ECI) is also relevant to current-account performance because it reflects the productive capabilities embedded in a country's export structure. Hidalgo and Hausmann (2009) introduced ECI as a measure of the diversity and sophistication of a country's productive structure. Countries with higher economic complexity are generally expected to produce and export more sophisticated goods, which may improve export competitiveness and support external-balance performance.

The impact of economic complexity on the current account is not always positive, however. As shown by the study conducted by Ünsal et al. (2025), economic complexity can have a negative impact on the current account balance in 66 countries depending on the structure and development level of the country. The reason for this may be that upgrading productivity often requires the importation of capital goods, intermediate inputs, and technology before it is able to improve export performance. Thus, if structural upgrading remains import-intensive, economic complexity may initially worsen the current account.

Economic complexity may also be linked to CO_2 emissions. In MENA countries and Turkey, AlAyouty (2024) examined the relationship between ECI, renewable energy, and CO2 emissions. Results indicate that renewable energy can reduce emissions, while economic complexity affects emissions in different ways depending on the energy structure and production pattern. It is relevant for Morocco since, depending on the level of industrial development and the composition of the economy, higher levels of productive complexity may accompany cleaner technologies or a higher level of energy demand.

As a whole, the literature suggests that renewable energy may improve the current account by reducing the dependence on fossil fuel imports, whereas CO2 emissions may weaken external sector performance by reflecting the use of carbon-intensive energy. Economic complexity can also affect the current account through export sophistication, although its effects can be mixed when productive upgrading is dependent on imported capital goods and intermediate inputs. In this study, we examine renewable energy, CO2 emissions, economic complexity, and current account dynamics in Morocco, a fossil-fuel-importing country in the MENA region.

3. The Data and the Methodology

This study uses annual Moroccan data for 2001–2022 to examine how the current-account balance is related to renewable energy consumption, industrial-process CO_2 emissions, and economic complexity. The current account, expressed as a percentage of GDP, is the dependent variable. Renewable energy consumption, the logarithm of industrial-process CO_2 emissions, and the Economic Complexity Index are included as explanatory variables. The long-run specification is written as:

$$CA_t = \beta_0 + \beta_1 RE_t + \beta_2 LCO2_t + \beta_3 ECI_t + \varepsilon_t$$

where CA_t denotes the current account, RE_t denotes renewable energy consumption, $LCO2_t$ denotes the natural logarithm of CO_2 emissions, ECI_t denotes the Economic Complexity Index, and ε_t is the stochastic error term.

Data on the current account and renewable energy consumption are taken from the World Bank's World Development Indicators. Renewable energy consumption is measured as the share of renewable energy in total final energy consumption. Industrial-process CO_2 emissions are measured in million tons of CO_2 equivalent and are transformed into logarithmic form. The Economic Complexity Index is obtained from the Observatory of Economic Complexity and is used to capture the diversity and sophistication of Morocco's export structure.

The empirical procedure begins by testing the order of integration of the variables using the Augmented Dickey–Fuller and Phillips–Perron tests. Since the variables are found to be integrated of order one, the Johansen cointegration test is used to examine whether a long-run relationship exists among them. The model is then estimated using a Vector Error Correction Model, which allows the analysis to distinguish between long-run adjustment and short-run movements.

The general VECM specification can be written as (Engle and Granger, 1987; Johansen and Juselius, 1990):

$$\Delta Y t_t = \alpha ECT_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$$

where Y_t is a vector that includes CA, RE, LCO2, and ECI; ECT_{t-1} is the lagged errorcorrection term derived from the cointegrating vector, α measures the speed of adjustment toward long-run equilibrium, and Γi captures the short-run coefficients. The lag length is selected using the Akaike Information Criterion and the Schwarz Criterion. Residual diagnostics are then used to check the adequacy of the estimated model. Granger causality tests, impulseresponse functions, and variance decomposition are also reported to assess the interactions among the variables.

4. Empirical Results and Discussion

Table 1 reports the descriptive statistics. The mean value of the current account is negative, indicating that Morocco recorded an average current-account deficit over the sample period. Renewable energy consumption shows relatively high dispersion compared with LCO_2 and ECI,

reflecting changes in Morocco's energy mix during the period under study. The negative mean of ECI suggests that Morocco's productive structure remained below the level associated with highly complex export economies.

Table 1: Descriptive Statistics

	CA	RE	LCO2	ECI
Mean	-2.3541	13.5546	5.1527	-0.7855
Median	-3.2602	11.72	5.23525	-0.766
Maximum	3.67558	22.36	6.411	-0.3628
Minimum	-8.9503	10.45	4.33	-1.1864
Std. Dev.	3.57569	3.36706	0.5123	0.21686
Skewness	0.14975	1.15205	0.39836	0.06478
Kurtosis	2.06066	3.45613	2.93325	2.69502
Jarque-Bera	0.89106	5.05719	0.58594	0.10064
Probability	0.64049	0.07977	0.74605	0.95092
Sum	-51.789	298.2	113.359	-17.281
Sum Sq. Dev.	268.497	238.079	5.51141	0.98763
Observations	22	22	22	22

The correlation results in Table 2 provide an initial view of the relationships among the variables. The current account is positively correlated with renewable energy consumption and negatively correlated with both LCO_2 and ECI. The negative correlation between CA and LCO_2 is consistent with the view that carbon-intensive activity may be associated with external-sector pressure. The positive correlation between LCO_2 and ECI also suggests that increases in productive complexity may still be connected to energy-intensive production patterns.

Table 2. Correlation Results

	CA	RE	LCO2	ECI
CA	1	0.65715	-0.8228	-0.5379
RE	0.65715	1	-0.5133	-0.7264
LCO2	-0.8228	-0.5133	1	0.37107
ECI	-0.5379	-0.7264	0.37107	1

The unit-root results in Table 3 show that none of the variables is stationary in levels. After first differencing, however, both the ADF and Phillips–Perron tests reject the unit-root null for all variables. CA, RE, LCO_2, and ECI are therefore treated as I(1) variables, which justifies the use of Johansen cointegration analysis.

Table 3. Unit root test

Variable	**ADF**		**PP**	
	Level	**First Difference**	**Level**	**First Difference**
CA	-1.8609	-3.9567***	-1.8591	-3.922***
RE	-1.1333	-4.1796***	-1.1333	-4.1718***
LCO2	-2.5651	-5.6295***	-2.4608	-6.1599***
ECI	0.0629	-3.665706**	0.0629	-3.65271**

The numbers refer to the test statistic results.

*, **, *** Denotes significance at 10%, 5%, and 1%, respectively.

Table 4 presents the Johansen cointegration results. Both the Trace and Maximum Eigenvalue tests reject the null hypothesis of no cointegration at the 5% level. The evidence therefore points to one cointegrating relationship among the variables. This supports the use of the VECM rather than a model estimated only in first differences.

Table 4. Johansen Cointegration Test Results

Hypothesis	Eigenvalue	Trace Test			Max Eigen Value		
		Trace statistics	0.05 Critical Value	P-value	Max-Eigen statistics	0.05 Critical Value	P-value
None*	0.728573	52.32965	47.85613	0.0179	28.68939	27.5843	0.036
At most 1	0.523372	23.64026	29.79707	0.2161	16.30241	21.1316	0.2077

* Denotes the rejection of the null hypothesis of no cointegration at 5% significance

The VECM estimates are reported in Table 5. The error-correction coefficient is negative and statistically significant, showing that deviations from the long-run relationship are corrected over time. The estimated coefficient implies that around 36.7% of disequilibrium is adjusted each year.

In the long run, LCO_2 is the only variable with a statistically significant coefficient. Its negative sign indicates that higher industrial-process CO_2 emissions are associated with a weaker current account balance. This result suggests that Morocco's external position remains sensitive to carbon-intensive production, especially where such activity depends on imported energy, machinery, and intermediate inputs.

Renewable energy consumption has a negative but statistically insignificant coefficient. This means that the estimated model does not provide clear evidence that renewable energy consumption has improved Morocco's current-account balance during the period examined. A possible explanation is that renewable-energy expansion may still involve substantial imports of equipment, technology, and infrastructure, limiting its immediate effect on the external balance.

The coefficient of ECI is also negative and statistically insignificant. This result suggests that economic complexity has not yet translated into stronger current-account performance. In Morocco's case, productive upgrading may still be associated with higher demand for imported capital goods and intermediate inputs before it produces a stronger export effect (see (Ünsal et al., 2025).

The short-run coefficients in Table 5 are not statistically significant. Thus, changes in renewable energy consumption, industrial-process CO_2 emissions, and economic complexity do not appear to explain short-run movements in the current account within this specification.

Table 5. VECM Long Run and Short Run Results

Column1	Coefficient	Standard Error	T. Statistics
Long Run			
RE(-1)	-0.3018	(0.2753)	[-1.09611]
LCO2(-1)	-6.0717**	(0.9375)	[-6.47642]
ECI(-1)	-9.2499	(5.4685)	[-1.69149]
Short Run			
ECT	-0.3673**	(0.1734)	[-2.11830]
Δ(CA(-1))	0.1638	(0.24017)	[0.68196]
Δ(RE(-1))	0.2360	(0.27218)	[0.86713]
Δ(LCO2(-1))	0.7949	(1.12502)	[0.70662]
Δ(LECI(-1))	4.7955	(6.52976)	[0.73441]
C	-0.2795	(0.53206)	[-0.52525]

** Denotes significance at 5% level.

Values in () and [] represent the *standard errors* and T-statistics, respectively.

The diagnostic tests in Table 6 indicate that the model does not suffer from residual serial correlation or heteroskedasticity at conventional significance levels. This supports the reliability of the estimated VECM.

Table 6. Residual Diagnostics Tests

Model	Chi-Square	Probability
VEC Residual Heteroskedasticity Tests (Levels and Squares)	95.91031	0.5971
VECM Residual Serial Correlation LM Tests	12.75767	0.7038

Table 7 reports the Granger causality results. The findings do not show short-run causality from RE, LCO_2, or ECI to the current account. However, there is weak evidence of causality from ECI to RE and from LCO_2 to ECI at the 10% level. These results suggest some interaction among the explanatory variables, but not a direct short-run transmission to the current account.

Table 7. VEC Granger Causality/Block Exogeneity Wald Tests Results

Independent Variables **Dependent Variables**	**Wald F-statistic of independent variables**			
	CA	***RE***	***LCO2***	**ECI**
CA	-	0.7519 (0.3859)	0.4993 (0.4798)	0.5394 (0.4627)
RE	0.0116 (0.9143)	-	0.0326 (0.8568)	2.9766* (0.0845)
LCO2	0.2179 (0.6407)	0.0002 (0.9887)	-	1.0405 (0.3077)
ECI	0.0039 (0.9501)	0.1133 (0.7364)	3.1445* (0.0762)	-

* denotes significance level at 10% level.

Values in () represent the p-values.

Table 8 shows the variance decomposition of the current account model. The results indicate that most variation in the current account is explained by its own shocks, although this share declines gradually over time. LCO_2 has the highest contribution among the independent variables, followed by ECI, while RE explains only a small share of CA fluctuations. This suggests that carbon-related factors are more relevant than renewable-energy shocks in explaining current account variability over the forecast horizon.

Table 8. VECM Variance Decomposition Results

Period	**S.E.**	**CA**	**RE**	**LCO2**	**ECI**
1	2.176065	100	0	0	0
2	3.066585	97.51962	0.265892	2.106349	0.108137
3	3.711633	95.00818	0.245172	4.201752	0.544892
4	4.205443	93.47061	0.425151	4.844253	1.25999
5	4.628617	92.01107	0.668955	5.591574	1.728399
6	5.015292	90.85137	0.900187	6.135852	2.11259
7	5.372125	90.02307	1.074351	6.513348	2.389233
8	5.706918	89.38108	1.207522	6.819334	2.592065

9	6.023513	88.87642	1.312091	7.05813	2.753357
10	6.324276	88.46975	1.395931	7.25102	2.883304

The impulse response results for CA are presented in Table 9. The impulse response function examines the response of the current-account balance to a one-standard-deviation shock in each variable over a ten-period horizon. CA responds positively to its own shock throughout the period, although the response gradually declines and stabilizes, suggesting that current-account shocks persist but become weaker over time.

CA initially responds positively to a shock to RE in the second period, but after the second period the response turns negative and stabilizes at the 3rd period. This suggests that renewable energy shocks may not immediately improve the current account, possibly because renewable energy expansion has not yet reached a sufficient scale and may still involve imported capital equipment, technology, and infrastructure before generating long-run benefits for the external balance. CA is consistently negatively affected by a shock to LCO2, indicating that Morocco's current account may be under pressure from carbon-intensive activities. Similarly, the response of CA to an ECI shock becomes negative after the second period, suggesting that increased productive complexity may be associated with import-intensive structural transformation.

Table 9. VECM Impulse Response Results

Period	CA	RE	LCO2	ECI
1	2.176065	0	0	0
2	2.106047	0.158128	-0.44506	0.100842
3	1.979356	-0.09365	-0.61706	-0.25475
4	1.855382	-0.20351	-0.52716	-0.38441
5	1.783692	-0.26101	-0.58413	-0.384
6	1.771847	-0.28828	-0.58772	-0.40136
7	1.768738	-0.28919	-0.57998	-0.39767
8	1.76919	-0.28848	-0.58417	-0.3933
9	1.770968	-0.28772	-0.58301	-0.39343
10	1.771439	-0.28681	-0.58247	-0.39272

5. Conclusion

This study examined the relationship between renewable energy consumption, industrial-process CO_2 emissions, economic complexity, and Morocco's current-account balance over the period 2001–2022. The results show that the variables are cointegrated and that the VECM adjusts toward the long-run relationship. The main finding is that industrial-process CO_2 emissions have a negative and statistically significant long-run effect on the current account. Renewable energy consumption and economic complexity, however, are not statistically significant in the estimated model. The short-run results also do not show significant effects on the current account.

These findings suggest that Morocco's external balance is still more strongly linked to carbon intensive production than to renewable-energy expansion. Renewable energy may improve the current account in the future, but this effect appears limited so far, possibly because the transition still depends on imported equipment, technology, and infrastructure.

The policy implication is that renewable-energy expansion should be accompanied by domestic industrial capacity, local technological development, and stronger export-oriented production. Without these complementary measures, the energy transition may deliver environmental benefits while having only a limited effect on external-sector performance. Future research could extend the analysis by using additional control variables, alternative estimators, or comparative evidence from other energy-importing MENA economies.

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