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Green Bonds As A Financing Mechanism For Energy Transition In Emerging Markets: The Case Of Morocco.

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Abstract
Energy transition is one of Morocco's key sustainable development issues, and is at the heart of the 2030 National Sustainable Development Strategy. On one hand, it reflects the Moroccan government's determination to reduce the negative impact of energy consumption on the environment, and on the other, its determination to rely essentially on renewable energies to meet its energy needs. With this in mind, several tools are being implemented, including green bonds designed to finance projects with a high environmental or climate impact. Thus, since 2015, several green bonds have been issued for a cumulative total of $0.4 Billion[1].
This article aims to examine the impact of green bonds on Morocco's energy transition. Through the Granger causality and cointegration test, this article examines the existence of a short- and long-term causal relationship between green bond issuance and investment in renewable energy projects on one hand, and between green bond issuance and CO2 emission reductions on the other.
The results suggest that there is no short-term causal relationship between green bond issuance and renewable energy investments on one hand and CO2 emissions reduction on the other hand. However, in the long run, there is a relationship between green bond issuance and CO2 emissions reduction in Morocco.

Keywords: *Climate impact, CO2 emissions, Energy transition, Green bonds, Morocco.*

Introduction

The energy transition is one of the main challenges of sustainable development in Morocco. The country, heavily dependent on fossil fuels, has committed to promoting renewable energy as part of its climate goals. To successfully transition to renewable energy sources, adequate financing is essential. In this context, green bonds, first issued in Morocco in 2016 by Masen, have emerged as a key financing mechanism to support sustainable development projects.
Since then, the cumulative volume of green bond issuances in Morocco has exceeded 10 billion dirhams, reflecting growing interest in these financial instruments. However, the question remains: do these green bonds genuinely contribute to increasing investments in renewable energy and to reducing the negative externalities, such as CO2 emissions, caused by industrial activities?
The aim of this study is to analyze the impact of green bonds on investments in renewable energy and on the reduction of CO2 emissions, focusing on the context of emerging markets, particularly

[1] IFC-Amundi Joint Report, Emerging Market Green Bonds, p.41

Morocco. More specifically, we seek to answer the following question: **What is the real impact of green bonds on investments in renewable energy and on reducing CO2 emissions in Morocco?**
To address this question, we first conducted a literature review to better understand the potential relationships between green bond issuances, investments in renewable energy, and the reduction of CO2 emissions. Following this, two empirical studies were carried out to test the existence of a causal relationship, both in the short and long term, between these variables. These studies rely on econometric models based on data covering the period from 2016 to 2022.
While this study provides valuable insights, it has an important limitation due to the short time frame of the analysis. The 2016-2022 period, dictated by the date of Morocco's first green bond issuance, is relatively limited to capture long-term dynamics. A longer study period, spanning several decades, would allow for a more comprehensive assessment of these relationships and yield more robust results. This limitation paves the way for future research that could extend and complement the findings presented here.
The article is structured in three parts : the first section presents a literature review, while the second and third sections are devoted to the empirical studies, each aiming to test the relationships between green bond issuances, investments in renewable energy, and the reduction of CO2 emissions in Morocco.

1. Literature review

The participation of green bonds in the energy transition can be divided into two parts: their impacts on investments in renewable energies on one hand and their contribution to reducing the negative externalities of the energy industries on the environment, such as CO2 emissions.
To this end, this literature review is structured into 3 sections. The first section presents the generalities on green bonds by presenting their role, the factors motivating their issues, their impacts on the management of issuers, and the obstacles to their development. The second section presents the empirical work that has focused on the relationship between green bond issues and investments in green projects. The third section presents the work on the relationship between green bond issues and CO2 emissions. These three sections pave the way for the empirical studies that will be carried out.

1.1. Green Bonds Overview

Green bonds are generally known to be an effective tool to connect funders with sustainability goals on one hand and sustainable development projects that need long-term financing on the other hand. (IRENA, 2020)[2].
With the rise of bonds, several authors have conducted studies on green bonds. For example, Aaron Maltais & Björn Nykvist conducted a study[3] on the role of green bonds in achieving sustainable development goals. They examined the factors motivating green bond issuances, and their impacts on how companies integrate sustainable development into management.

[2] IRENA (2020), Renewable Energy Finance, Green Bonds (2020), Renewable Energy Finance Brief, 03 p.6
[3] Aaron Maltais and Björn Nykvist (2020): Understanding the role of green bonds in advancing sustainability, Journal of Sustainable Finance & Investment, DOI:10.1080/20430795.2020.1724864

Regarding the factors motivating issuances, Aaron Maltais & Björn Nykvist identify three categories of factors: financial factors including low cost of capital, reduced financial risk, greater accessibility to financing; institutional factors including stakeholder pressure, the search for legitimacy to operate; economic factors including brand image, operational efficiency and access to new markets. Regarding the impacts on the way companies integrate sustainable development into management, Aaron Maltais & Björn Nykvist show that green bond issuances push issuers themselves to take measures that reflect their commitment to achieving sustainable development goals: reducing pollution, better water and waste management. Despite the benefits of green bond issuances, their growth is hampered by a number of factors. To highlight them, Bartosz Sobik (2023) conducted a study[4] on the obstacles to the development of green bonds through the case of Poland. Through a documentary research, it shows that high transaction costs, the lack of sufficiently high economic gains for issuers constitute major obstacles to the development of green bonds. It also highlights that green bonds are not intended to finance all environmental projects, however, they make their modest contribution to the transition to sustainable development.

Here are briefly the obstacles hindering the development of green bonds. In the following lines we will discuss the literature review on the existing relationship between green bonds and investments in renewable energies.

1.2. The existing relationship between green bonds and investments in renewable energies

Several authors have shown how green bonds can meet the financing needs of industries operating in the renewable energy sector.

Shakizada Niyazbekova, Luiza Moldashbayeva, Seyit Kerimkhulle, Nurdin Dzholdoshev, Tamara Dzholdosheva and Madina Serikova (2023)[5] examined the role of green bonds as a financing mechanism for sustainable development projects. They show that green bonds are more attractive to investors financially compared to conventional bonds because beyond the normal yield, green bonds offer an additional “green” yield. This leads to a certain shift of capital towards green projects including renewable energy projects including solar energy, wind energy, and hydropower.

Farhad Taghizadeh-Hesary, Han Phoumin and Ehsan Rasoulinezhad (2023) also conducted a study[6] on the impact of green bond issuance on investments in three different types of renewable energy: solar energy, wind energy, and hydropower. The data of the study come from the Japanese market and cover the period from 1990 to 2020. These three researchers use autoregressive distributed lag (ARDL). The results show that green bond issuances lead to an increase in the use of solar energy and hydropower, consequently an increase in investments in these two areas. Regarding wind energy, the study notes that bond issuances have no impact in the short term because of geopolitical risks in the case of Japan.

[4] Bartosz Sobik (2023), Green bonds - financial innovation for sustainability financing: The case of the Polish green bonds market and their development barriers . Central European Economic Journal, 10(57), 287-303.

[5] Shakizada Niyazbekova, Luiza Moldashbayeva, Seyit Kerimkhulle, Nurdin Dzholdoshev, Tamara Dzholdosheva and Madina Serikova (2021), "Green" bonds – a tool for financing "green" projects in countries, E3S Web of Conferences 244, 10060 (2021) https://doi.org/10.1051/e3sconf/202124410060 EMMFT-2020

[6] Farhad Taghizadeh-Hesary, Han Phoumin and Ehsan Rasoulinezhad (2023), Assessment of role of green bond in renewable energy resource development in Japan, Resources Policy, Volume 80, 103272, ISSN 0301-4207,

Yang Wang and Farhad Taghizadeh-Hesary (2023) also conducted a study[7] on the impact of green bond issuances on consumption and investments in renewable energy, more precisely solar energy, wind energy and hydropower. The data come from 15 OECD countries (Austria, Belgium, Canada, Demark, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States) and cover the period from 2010 to 2020. The study uses fully modified OLS (FMOLS) technique. The results show that green bonds do not significantly impact investments in solar energy in OECD countries unlike other energies.

Overall, green bonds positively impact investments in renewable energies. However, investments in solar and wind energy do not follow the trend of bond issuance in certain geopolitical contexts. In the following lines, we will discuss the work that has focused on the relationship between green bonds and CO2 emissions.

1.3. Green bonds and reduction of CO2 emissions

The impact of green bond issues on CO2 emissions has been addressed by several authors keen to assess the role of green bond issues in the fight against global warming.

In this dynamic, Serena Fatica and Roberto Panzica (2020) conducted a study[8] on the impact of green bond issues on CO2 emissions. The data covers 1011 green bond issuers including 92 companies. The study uses the Flammer and Coarsened exact matching methodology. The results of the study show that green bond issuers reduce their own CO2 emissions after their issues compared to bond issuers with similar environmental and financial scores. This reduction is much more pronounced for green bond issuers whose funds are exclusively dedicated to projects with a positive impact on climate change, and for green bonds that have an external review.

Nini Johana Marín-Rodríguez, Juan David González-Ruiz and Sergio Botero (2002) also obtained similar results. They conducted a study[9] on the dynamic relationships between green bonds, CO2 emissions and oil prices. The data come from 2206 daily observations covering the period from January 01, 2014 to June 15, 2022. The study uses the Granger causality test and the Dynamic Conditional Correlation (DCC-Garch) Model. The results of the study show that there is undoubtedly a dynamic relationship between green bonds, CO2 emissions and oil prices. This is consistent with the fact that these three variables are intrinsically connected in industrial operating cycles. The results also show the existence of a unidirectional causal relationship between green bond issuance and CO2 emission reduction.

Mazzacurati Julien and Paris William also conducted a study[10] on the environmental impact of green bond issuances. The data covers the period from 2009 to 2019 and covers banks, utilities and energy firms that have issued green bonds. The results show that green bond issuances lead to a significant reduction in CO2 emissions for issuers. This is consistent with the fact that green bond issuances are

[7] Yang Wang and Farhad Taghizadeh-Hesary (2023). Green bonds markets and renewable energy development: Policy integration for achieving carbon neutrality. Energy Economics. 123. 106725. 10.1016/j.eneco.2023. 106725.

[8] Serena Fatica and Roberto Panzica (2020), Green bonds as a tool against climate change? JRC Working Papers in Economics and Finance, 2020/10

[9] Nini Johana Marín-Rodríguez, Juan David González-Ruiz and Sergio Botero (2022), Dynamic relationships among green bonds, CO_2 emissions, and oil prices, Front. Environ. Sci., Sec. Environmental Economics and Management, Volume 10 - 2022 | https://doi.org/10.3389/fenvs.2022.992726

[10] Mazzacurati Julien and Paris William (2021), Environmental impact and liquidity of green bonds. ESMA Report on Trends, Risks and Vulnerabilities No. 2.

a signal showing the issuer's commitment to combating global warming. Rupjyoti Saha, Santi Gopal Maji (2023)[11] examined the existence of a causal relationship between green bond issuances and CO2 emission reduction in developed and developing countries. The data covers the period from 2016 to 2020 and covers 44 countries. A panel data regression model was used to analyze the impact of green bond issuances on CO2 emission reduction. The study also uses the Generalized methods of moments (GMM) and instrumental variables (IV) models for robustness. The results show the existence of a strong negative correlation between green bond issuances and CO2 emissions in developed and developing countries.

All these studies converge on the fact that green bond issuances lead to a reduction in CO2 emissions. Now, it is necessary to conduct empirical studies to see the case of Morocco. Before conducting a causality study between green bond issuances and the reduction of CO2 emissions in Morocco, we will first conduct a causality study between green bond issuances and investments in renewable energy.

2. Causality study between green bond issuances and investments in renewable energy

This section is dedicated to a causality study between green bond issuances and investments in renewable energy. In other words, the aim is to see whether green bond issues cause an increase in renewable energy investments in Morocco and vice versa. The data covers the period from 2016 to 2022, because the first green bond issue in Morocco was in 2016 and last year (2023), there were no green bond issues. The objective of this section is to answer the following questions:

- Do green bond issues cause renewable energy investments in Morocco in **the short term** or vice versa?
- Do green bond issues cause renewable energy investments in Morocco in **the long term** or vice versa?

To answer each of these questions, the Granger causality test will be carried out followed by the cointegration test.

2.1. Granger causality test

This involves seeing whether green bond issues cause investments in renewable energy in the short term (Gb → Re) or whether investments in renewable energy cause green bond issues in the short term (Re → Gb). Re denotes the variable relating to investments in renewable energy and Gb that relating to green bond issues. The Granger causality test provides the following two estimates:

Estimate 1: $$Re_t = \sum_{i=1}^{n} a_i Re_{t-i} + \sum_{j=1}^{n} \beta_j Gb_{t-j} + u_t$$

Estimate 2: $$Gb_t = \sum_{i=1}^{n} \gamma_i Gb_{t-i} + \sum_{j=1}^{n} \delta_j Re_{t-j} + v_t$$

By default, the error estimates u_t and v_t are uncorrelated.

Estimate 1 means that renewable energy investments (Gb) at a given time are related to its past values and to green bond issuances (Gb) in the past. Estimate 2 means that green bond issuances (Gb) at a given time are related to its past values and to renewable energy investments in the past.

[11] Rupjyoti Saha, Santi Gopal Maji (2023), Do green bonds reduce CO2 emissions? Evidence from developed and developing nations, International Journal of Emerging Markets, ISSN:1746-8809

Since only the past can cause the present and/or the future, if green bond issuances (Gb) cause renewable energy investments (Re) then the change in the value of the variable Gb (green bond issuances) should precede the change in the value of the variable Re (renewable energy investments). This reasoning is valid in the opposite direction, i.e. in the case where renewable energy investments (Re) cause green bond issuances (Gb).

Green bond issuance causes renewable energy investments: Gb → Re

The hypotheses are presented as follows:

Ho: Green bond issuance does not cause renewable energy investments

H1: Green bond issuance causes renewable energy investments

Green bond issuance is assessed and renewable energy investments are assessed per year in billions of dirhams. The values are presented in the table below.

Year	Green bond issues (in billions MAD)	Investments in renewable energy (in billions MAD)
2016	1,15	10,5
2017	2,5	12
2018	2	11,5
2019	2	13
2020	0,355	12,5
2021	2,5	14
2022	1	15

The unconstrained and constrained models of the causality test are written as follows:

The unconstrained model: $Re_t = C + a_1 Re_{t-1} + \beta_1 Gb_{t-1} + u_t$

The constrained model: : $Re_t = C + a_1 Re_{t-1} + u_t$

To estimate the unconstrained model, we will use a simple linear regression on the eviews software. This gives the following result.

Dependent Variable: RE
Method: Least Squares
Date: 09/19/24 Time: 00:43
Sample (adjusted): 2017 2022
Included observations: 6 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.076387	4.757551	0.646632	0.5639
RE(-1)	0.897903	0.408764	2.196629	0.1155
GB(-1)	-0.614393	0.588670	-1.043698	0.3733

R-squared	0.620390	Mean dependent var	13.00000
Adjusted R-squared	0.367316	S.D. dependent var	1.303840
S.E. of regression	1.037093	Akaike info criterion	3.217574
Sum squared resid	3.226688	Schwarz criterion	3.113454
Log likelihood	-6.652722	Hannan-Quinn criter.	2.800772
F-statistic	2.451420	Durbin-Watson stat	2.778273
Prob(F-statistic)	0.233888		

This linear regression allows us to identify the following unconstrained model:

The unconstrained model : : $Re_t = 3.076387 + 0.897903\ Re_{t-1} - 0.614393\ Gb_{t-1} + u_t$

$R^2 = 0.620390$; n = 7 ; SCRU = 3.226688

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To estimate the constrained model, we will use a linear regression of the variable 〖Re〗_ten as a function of a constant C and the variable Re_{t-1}. This gives the following result.

Dependent Variable: RE
Method: Least Squares
Date: 09/19/24 Time: 00:44
Sample (adjusted): 2017 2022
Included observations: 6 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.864407	4.749405	0.813661	0.4615
RE(-1)	0.745763	0.386128	1.931386	0.1256

R-squared	0.482552	Mean dependent var	13.00000
Adjusted R-squared	0.353190	S.D. dependent var	1.303840
S.E. of regression	1.048607	Akaike info criterion	3.194004
Sum squared resid	4.398305	Schwarz criterion	3.124590
Log likelihood	-7.582011	Hannan-Quinn criter.	2.916136
F-statistic	3.730250	Durbin-Watson stat	2.789589
Prob(F-statistic)	0.125615		

This linear regression allows us to have the constrained model.
The constrained model: $Re_t = 3.864407 + 0.745763\ Re_{t-1} + u_t$
$R^2 = 0.482552$; n = 7 ; SCRR = 4.398305

- Calculation of the F statistic

$$F = \frac{(SCRR-SCRU)/c}{SCRU/(n-c-1)} = \frac{(4.398305-3.226688)/1}{3.226688/(7-1-1)} = 1.82$$

- Calculation of the critical value of F

$$Fs = F^{0.05}_{(n-k-1)} = 6.61$$

- Test result

The F-statistic is less than its critical value Fs at a certain significance level, in this case 5%. We therefore accept hypothesis Ho. Green bond issuance does not cause investments in renewable energy.

❖ Renewable energy investments cause short-term green bond issuance: Re → Gb

The hypotheses are presented as follows:
Ho: Renewable energy investments do not cause short-term green bond issuance
H1: Renewable energy investments cause short-term green bond issuance
From estimate 2, we can write the constrained and unconstrained models:

Unconstrained model: $Gb_t = C + \gamma_1\ Gb_{t-1} + \ \delta_1\ Re_{t-1} + \ v_t$
Constrained model: $Gb_t = C + \gamma_1\ Gb_{t-1} + \ v_t$
The coefficients of the unconstrained model are obtained from a linear regression of the variable Gb_t as a function of the variable Gb_{t-1} and the variable Re_{t-1}. Which gives the following result.

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Dependent Variable: GB
Method: Least Squares
Date: 09/19/24 Time: 01:00
Sample (adjusted): 2017 2022
Included observations: 6 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.418217	3.105758	2.388536	0.0969
GB(-1)	-0.397192	0.384287	-1.033582	0.3773
RE(-1)	-0.407916	0.266844	-1.528669	0.2238

R-squared	0.633804	Mean dependent var	1.725833
Adjusted R-squared	0.389674	S.D. dependent var	0.866605
S.E. of regression	0.677021	Akaike info criterion	2.364624
Sum squared resid	1.375072	Schwarz criterion	2.260503
Log likelihood	-4.093871	Hannan-Quinn criter.	1.947822
F-statistic	2.596172	Durbin-Watson stat	2.406267
Prob(F-statistic)	0.221600		

This regression allows us to write the unconstrained model as follows::

Unconstrained model : $Gb_t = 7.41821 - 0.397192\ Gb_{t-1} - 0.49416\ Re_{t-1} + v_t$
R^2 =0.633804 ; n = 7 ; SCRU = 1.375072
To estimate the coefficients of the constrained model, we perform a simple linear regression of the variable Gb_t as a function of the variable Gb_{t-1}
This gives the following result..

Dependent Variable: GB
Method: Least Squares
Date: 09/19/24 Time: 01:02
Sample (adjusted): 2017 2022
Included observations: 6 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.788035	0.793156	3.515116	0.0246
GB(-1)	-0.606684	0.414698	-1.462954	0.2173

R-squared	0.348559	Mean dependent var	1.725833
Adjusted R-squared	0.185699	S.D. dependent var	0.866605
S.E. of regression	0.782013	Akaike info criterion	2.607310
Sum squared resid	2.446174	Schwarz criterion	2.537896
Log likelihood	-5.821929	Hannan-Quinn criter.	2.329442
F-statistic	2.140234	Durbin-Watson stat	1.739412
Prob(F-statistic)	0.217309		

These results allow us to write the constrained model as follows:

Constrained model: $Gb_t = 2.788035 - 0.606684\ Gb_{t-1} + v_t$
R^2 = 0.348559 ; n = 7 ; SCRR = 2.446174

• Calculation of the F statistic

$$F = \frac{(SCRR-SCRU)/c}{SCRU/(n-c-1)} = \frac{(2.446174-4.398305)/1}{4.398305/(7-1-1)} = 3.894$$

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• Calculation of the threshold of the F statistic

$Fs = F_{(n-k-1)}^{0.05} = 6.61$

• Test result

The F statistic is lower than its critical value Fs at a certain significance level, in this case 5%. We therefore accept the hypothesis Ho. Investments in renewable energy do not cause green bond issuance in the short term.

The Granger causality test on the eviews software confirms almost the same results as can be seen in the image below.

Pairwise Granger Causality Tests
Date: 09/19/24 Time: 10:34
Sample: 2016 2022
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
RE does not Granger Cause GB	6	2.33683	0.2238
GB does not Granger Cause RE		1.08931	0.3733

The probability that green bond issues do not cause renewable energy investments is 37%, greater than 5%. We can therefore accept Ho. Similarly, the probability that renewable energy investments do not cause green bond issues is 22%, greater than 5%. We can therefore accept Ho. All in all, green bond issues do not cause renewable energy investments in Morocco, and vice versa, during these first 7 years of bond issues.

Now, it is important to run the long-term causality tests.

1.1. Cointegration test and error correction mechanism

From an economic perspective, two variables are said to be cointegrated when there is a long-term relationship between them. This relationship is also called an equilibrium relationship. The purpose of the cointegration test is to see if there is an equilibrium relationship between green bond issues and investments in renewable energy.

❖ Cointegration test: Gb and Re

The Engel and Granger method consists of two main steps. The first consists of testing the order of integration of the variables and the second consists of estimating the equilibrium relationship.

1st Step: Testing the order of integration of Gb and Re

The single root test of green bond issues on the eviews software allows to have the result presented below.

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Null Hypothesis: GB has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.874349	0.0344
Test critical values:	1% level	-5.119808	
	5% level	-3.519595	
	10% level	-2.898418	

*MacKinnon (1996) one-sided p-values.

The probability that green bond issues (Gb) have a single root is 3.44%, lower than the 5% threshold. We can therefore reject the null hypothesis. The variable Gb is stationary at the order of differentiation 0. The order of integration of the variable is therefore 0.

Furthermore, the single root test of renewable energy investments on the eviews software without any differentiation allows us to have the following result:

Null Hypothesis: RE has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.732051	0.9950
Test critical values:	1% level	-5.604618	
	5% level	-3.694851	
	10% level	-2.982813	

*MacKinnon (1996) one-sided p-values.

The probability that renewable energy investments have a single root is 99.5%, much higher than 5%. We can therefore accept the null hypothesis. The variable Re has a single root. It is therefore not stationary at the order of differentiation 0.

All in all, the variables Gb and Re are not integrated at the same order. We can therefore no longer continue to estimate the long-term relationship between the two variables. In the following lines, we will examine the relationship between green bond issuance and CO2 emission reduction.

2. Causality study between green bond issuance and CO2 emissions reduction

This section is dedicated to a causality study between green bond issuance and CO2 emissions reduction. In other words, it is about seeing whether green bond issuance causes a reduction in CO2 emissions in Morocco and vice versa. The data cover the period from 2016 to 2022. The objective of this section is to answer the following questions:

• Do green bond issuance cause the reduction of CO2 emissions in Morocco in the **short term** or vice versa?

• Do green bond issuance cause the reduction of CO2 emissions in Morocco in the **long term** or vice versa?

To provide an answer to each of these questions, the Granger causality test will be carried out followed by the cointegration test.

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1.1. Granger Causality Test

The Granger causality test will determine whether green bond issues cause the reduction of CO2 emissions in Morocco in the short term or vice versa.

Green bond issues are always represented by the variable Gb in billions of MAD. The reduction of CO2 emissions is represented by the variable Cr expressed in Millions of tons. This variation is calculated by evaluating the variation in emissions from one year to the previous year. The table below shows the values of these variables over the period 2016-2022.

Year	Green bond issues (in billions MAD)	Total CO2 Emissions in Morocco (Mt)	CO2 Reduction in Morocco (Mt)
2016	1,15	58,46	-0,04
2017	2,5	61,11	2,65
2018	2	62,31	1,20
2019	2	68,74	6,43
2020	0,355	64,56	-4,18
2021	2,5	72,64	8,08
2022	1	68,41	-4,23

The Granger causality test is not detailed in this section. The previous section presents all the details of the test procedure. For the sake of brevity, the test is performed directly on the eviews software. The test results are presented in the table below:

Pairwise Granger Causality Tests
Date: 09/19/24 Time: 10:52
Sample: 2016 2022
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
GB does not Granger Cause CR	6	1.62187	0.2925
CR does not Granger Cause GB		9.05269	0.0573

The probability that green bond issues do not cause the reduction of CO2 emissions is 29%, well above the 5% threshold. We can therefore accept the null hypothesis. Similarly, the probability that the reduction of CO2 emissions causes green bond issues is 5.73%, higher than 5%. We can therefore accept the null hypothesis.

All in all, there is no Granger causality relationship in the short term between green bond issues and the reduction of CO2 emissions in Morocco. In the following lines, we will examine the existence of a possible long-term relationship.

1.2. Cointegration test and error correction mechanism

The aim is to see whether there is a balance between green bond issuance and CO2 emissions reduction.

❖ Cointegration test: Gb and Cr

The first is to test the order of integration of the variables and the second is to estimate the equilibrium relationship.

1st Step: Testing the order of integration of Gb and Re

The single root test of green bond issues on the eviews software made it possible to conclude in the previous cointegration test that the variable Gb is stationary at the order of differentiation 0. The order of integration of the variable is therefore 0.

Furthermore, the single root test of the reduction of CO2 emissions on the eviews software makes it possible to have the following result:

Null Hypothesis: CR has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.901717	0.0003
Test critical values:	1% level	-5.119808	
	5% level	-3.519595	
	10% level	-2.898418	

*MacKinnon (1996) one-sided p-values.

The probability that the variable Cr (CO2 emissions reduction) has a single root without any differentiation is 0.03% lower than the 5% threshold. We can therefore reject Ho. The variable Cr is therefore stationary without any differentiation.

The two variables Gb and Cr are stationary without any differentiation. The order of integration of these two variables is 0. We can therefore estimate the long-term relationship between these two variables using the eviews software.

❖ Estimation of the long-term relationship

The estimation of the long-term relationship between the variables Gb and Cr by linear regression on the eviews software gives the following result:

Dependent Variable: CR
Method: Least Squares
Date: 09/19/24 Time: 13:41
Sample: 2016 2022
Included observations: 7

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.737893	2.452345	-2.747531	0.0404
GB	4.961485	1.354419	3.663182	0.0145

R-squared	0.728540	Mean dependent var	1.416661
Adjusted R-squared	0.674248	S.D. dependent var	4.769348
S.E. of regression	2.722092	Akaike info criterion	5.075634
Sum squared resid	37.04891	Schwarz criterion	5.060180
Log likelihood	-15.76472	Hannan-Quinn criter.	4.884623
F-statistic	13.41890	Durbin-Watson stat	2.074619
Prob(F-statistic)	0.014546		

From this result, we can write the long-run relationship between green bond issuance and long-run CO2 emissions reduction as follows:

$$Cr_t = -6.737893 - 4.961485\ Gb_t$$

The model appears significant with a p-value associated with the Gb variable of 1.45%, well below the 5% threshold.

Conclusion

With its first green bond issue in 2016 by Masen, Morocco has continued to see new green bond issues. The cumulative amount of green bond issues now exceeds 10 billion dirhams. And this is expected to foster investments in renewable energy in order to reduce negative externalities on the environment.

To this end, we conducted two empirical studies on the relationship between green bond issues and investments in renewable energy on one hand, and between green bond issues and the reduction of CO2 emissions on the other hand. The results of the empirical studies do not reveal a short-term causal relationship between green bond issues and investments in renewable energy on one hand and the reduction of CO2 emissions on the other hand. However, there is a long-term relationship between green bond issues and the reduction of CO2 emissions. And this is consistent with the fact that renewable energy projects generally extend over a period of 10 to 30 years, sometimes even longer. Their effects cannot therefore be felt in the short term, but essentially in the long term.

Like any empirical study, this study has a limitation relative to the 2016-2022 horizon. This is due to the fact that the first green bond issue in Morocco took place in 2016. And in 2023, there were no green bond issues. This 2016-2022 horizon is short. A longer horizon of 30 years would make it possible to better capture the relationships between these variables. This limitation opens the way to other empirical studies that could provide complementary answers.

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