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Exploring the Relationship Between Green Bond Issuance and Energy-related SDGs in Emerging Market and Developing Economies

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Abstract

In emerging market and developing economies (EMDEs), funds available for enabling the net-zero carbon transition are far below the level of investment required for a successful accomplishment. Nevertheless, a lot of EMDEs are making serious endeavours to deploy green financial instruments to support the transition. Among the internationally available financial instruments, green bonds (GBs) are especially significant due to their internationally regulated taxonomy, principles and classification of use of proceeds. The effectiveness of GB issuance is hard to measure but its relatedness to sustainable development goals (SDGs) has been proposed by the literature. This paper investigates the relationship between GB issuance and energy-related SDGs on the basis of a sample of 75 EMDEs in the period between 2000 and 2022. Besides renewable energy use and energy intensity, achievement of the ultimate goal of sustainable finances, carbon dioxide emission reduction, is also evaluated based on country-level statistics. We find only a few countries where all indicators have moved in the desired direction since the first issue of green bonds, and even fewer where this positive trend has persisted afterwards. Even when the short time series available for analysis is taken into account, the findings suggest that the dominance of renewable energy investment among the uses of GB proceeds does not necessarily entail any progress towards the net-zero emission targets. Overall, this highlights the necessity of stronger policy commitment and control.

Keywords

sustainable development, CO_2 emission, renewable energy, EMDEs, green bonds

1 Introduction

Green bonds (GB) first appeared in the financial markets through the issues of multinational development banks, then first became widely used by advanced economies, spreading to emerging and developing markets only after 2010. At present, emerging markets account for a significant share of their yearly issue, with China in the lead. Throughout the years of their existence, GB markets have become more and more meticulously regulated, while governmental commitments to net-zero carbon emissions and other sustainability goals have increased in number and importance. The acceptance of the GB principles of the International Capital Market Association and the EU Taxonomy for sustainability of activities serve as a basis for their standardisation which is supplemented by a number of nationwide rules, regulations and innovations which have also affected Islamic financial products. The IFC-Amundi Joint Report (Amundi-IFC, 2024) on emerging market GBs now provides an assessment of the green, sustainable and social bonds of more than 70 countries. This paper investigates the contribution of the use of GBs to the mitigation of carbon emission and energy reforms in 75 emerging and developing markets, among which 73 have been listed by the IFC-Amundi Joint Report (Amundi-IFC, 2024) as Sustainable Banking and Finance Network (SBFN) members or GB issuers in 2024, while Mauritius was included due to its active participation in the GB markets, plus Croatia on account of its geographical vicinity to the Central European markets. 21 out of these economies had not launched GBs in financial markets; consequently, they serve as a control group in the investigation (see the list of these economies in Appendix A).

In the cumulative global issuance up to 2022 it is transport, energy, climate change adaptation and green construction that have taken the lead in investment realised from GB proceeds; collectively these account for a greater

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share than funds dedicated specifically to renewable energy investment (Fig. 1). In contrast, the joint reports of IFC-Amundi reveal that emerging markets spend the majority of funds raised through GB issuance on renewable energy related establishments (Fig. 2). Amid the cumulative issuance of GBs in the less advanced world 45% was dedicated to renewable energy investment in the period up to 2021 (Amundi-IFC, 2022). The share of renewables further increased in 2024 from 37–38% in 2022 and 2023 to 50% (Amundi-IFC, 2025:p.32).

It is therefore reasonable to investigate whether investment in renewables is significantly connected to a country's achievements in the use of renewable energy and other energy-related sustainable development goals (SDGs) as well as the extent to which these energy-related advancements serve the fulfilment of the net zero-emission goal. These questions are partly answered by using country-wise correlation analysis, and partly by Autogressive Distributed Lag (ARDL) panel regression for the entire sample in the paper.

The paper starts with a literature review summarising empirical results on the contribution of green financial

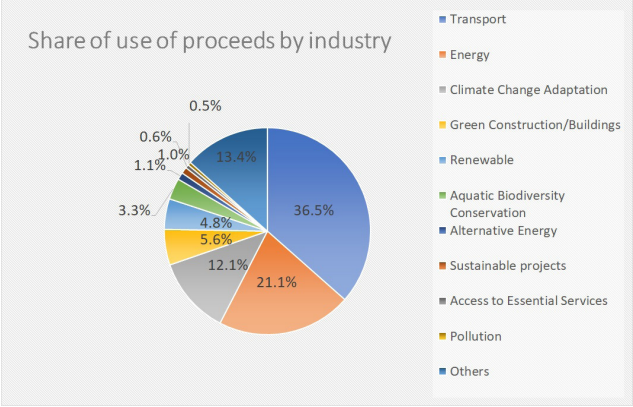

Fig. 1 Industrial share of GB proceeds–global cumulative issuance in 2022 (Source: IMF (online); own compilation)

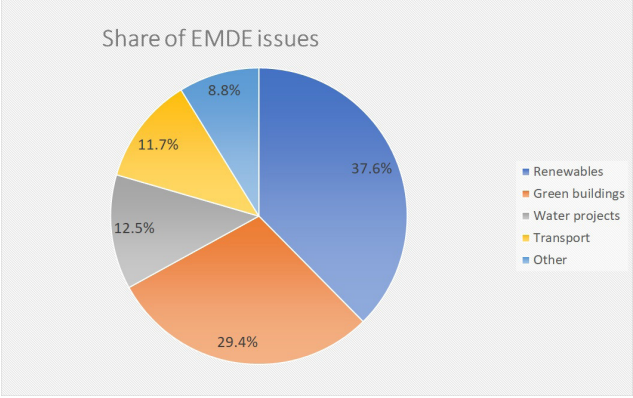

Fig. 2 Industrial share of EMDE issues in 2023 (Notes: "other" covers waste, land, industry and unallocated (Source: Amundi-IFC (2024:p.25)))

instruments to SDGs from a global perspective and the major results in the emerging market and developing economies (EMDEs) in developing their GB markets. Section 3 delineates the indicators and statistical methods used, the Section 4 presents the classification of countries based on their overall performance in the selected SDGs with correlation analysis and the results of the regression analysis, and the conclusion reveals the importance of the major findings and their policy implications.

2 Literature review

With the increasingly severe global challenges posed by climate change, green finance has gradually become one of the core instruments to promote sustainable economic development. In particular, GBs, as an important tool connecting financial capital and environmental protection goals, have been gaining ground in the international financial system. Section 2 provides a systematic review of GB-related studies in emerging economies and developing countries, covering the current status of regional development, environmental and economic impacts, policies and institutional development, assessment mechanisms and challenges, etc., thereby providing a theoretical foundation and practical inspiration for the research.

2.1 Green finance and SDG goals

In recent years, GBs have attracted increasing attention from policymakers and academics as a key tool for bridging the SDGs and the financial system (Ahmed et al., 2024). At the theoretical and macro levels, the contribution of GBs to climate change mitigation and the promotion of the SDGs has been empirically justified. Alamgir and Cheng (2023) evaluate the relationship between GBs and SDGs based on data from 67 countries including the United States, Canada, and China. They find that GB issuance is significantly negatively correlated with per capita carbon dioxide (CO_2) emissions and significantly positively correlated with renewable energy output, especially after the signing of the Paris Agreement, reflecting its increasingly supportive effect on SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) (see in "SDG goals" (UN, online)).

At the mechanism level, GBs not only serve as a financing channel, but also play the role of "policy signals" in regulating the behaviour of enterprises and the capital market. Ahmed et al. (2024), whose research is based on CAPM, the Fama-French multifactor model and Carhart four-factor model, show that GB issuance announcements can significantly generate excess returns in the stock market, indicating that investors regard them as positive signals

of corporate environmental responsibility and medium- to long-term sustainability strategies. It enhances the market attractiveness and incentive effect of green financing tools in advancing SDG 13.

Furthermore, there is significant heterogeneity in the promotion of GBs in SDGs due to the different institutional requirements, regulatory capabilities and financial development levels in different countries. Based on 2023 bonds data of the European Union, Australia, Canada, the United Kingdom and the United States, Caliari (2024) employs OLS regression and finds that, compared to conventional bonds, GBs significantly enhance SDG scores. This effect is more pronounced in countries with stronger regulatory frameworks and policy support. However, GBs may have a negative impact on firms' short-term financial performance (e.g., Return on Assets (ROA)), suggesting that the effectiveness of green investments should be evaluated from a long-term perspective. Focusing on East and South Asian countries, Das and Singh (2024) systematically assess the role of GBs in achieving multiple SDGs (6, 7, 9, 11, 13, and 15) (see in "SDG goals" (UN, online)) using a random forest and support vector machine approach. It is found that GBs can be an effective means of financing to bridge the fiscal gap, can effectively contribute to sustainable development in the areas of clean energy, infrastructure development, and climate action, and can help to promote the implementation of Nationally Determined Contributions (NDCs). Bhatnagar et al. (2024) construct a green finance and investment index covering four dimensions: transparency, resilience, efficiency and effectiveness, and conduct a comprehensive assessment of 15 countries. The results show that developed countries such as the UK and Germany have relatively mature green finance ecosystems, and China ranks high among developing countries. The study points out that improving regulatory transparency not only enhances the resilience of the financial system but also helps to improve the efficiency of capital allocation and provide institutional safeguards for the long-term impact of GBs. Moreover, although the GB market in Africa remains at an early stage of development and exhibits uneven progress across jurisdictions, countries such as Nigeria, South Africa, Morocco, Namibia, and Kenya have experienced rapid expansion in recent years. These markets have provided crucial financing for local infrastructure development and improvements in energy efficiency (Taghizadeh-Hesary et al., 2022). Such green financing initiatives not only support the achievement of Climate Action (SDG 13) and accelerate the transition to Affordable and Clean Energy (SDG 7) but also contribute positively to the development of Sustainable Cities and Communities (SDG 11).

2.2 Emerging market GBs

According to the Emerging Markets Green Bonds Report (Amundi-IFC, 2024), the green, social, sustainability, and sustainability-linked (GSSS) bond issuance in EMDEs grew 45% in 2023 compared to the same period last year, reaching an all-time high of $209 billion (Amundi-IFC, 2024). As an important participant in the global GB market, the Chinese market scale has expanded rapidly since the issuance of its first GB in 2014. By 2023, China's cumulative GB issuance have surpassed $400 billion, ranking first in the world for two consecutive years (CBI and CIB Research, 2024). In response to the rapid development of China's GB market, many scholars have conducted in-depth studies from the perspectives of green innovation (Rao et al., 2022), policy mechanism (Bhutta et al., 2022; Lin and Hong, 2022) and environmental performance (Luo and Lyu, 2024), exploring the role of emerging market GBs in promoting the realisation of the SDGs and its internal mechanism. In addition, Ge (2025) systematically analyses which factors affect the interest rates of China's GB issuance, and their findings provide an important reference for EMDEs in improving the pricing system of the GB market and enhancing the attractiveness of the market. Ezzuddin (2024) provides an in-depth analysis of the role of Islamic banks and capital markets in Malaysia in promoting SDGs, pointing out that through the issuance of green sukuk, the strengthening of sustainable governance structures, and the disclosure of environmental and social performance, there will be a positive contribution to the SDG-related goals (such as SDG 6, 7, 9, 11, 12, 13, etc.) (see in "SDG goals" (UN, online)). Haddad and Rokhim (2022) point out that the active participation of Indonesian investors in the GB market has not only facilitated the financing of environmentally friendly projects, but also promoted the realisation of goals such as Climate Action (SDG 13), Affordable and Clean Energy (SDG 7), and Sustainable Cities and Communities (SDG 11) (see in "SDG goals" (UN, online)).

GB research in Latin America and the Caribbean (LAC) started late but is growing rapidly, playing a key role in the GB market and global natural capital. In 2023 GB issuance in the region grew 88% year-on-year (Amundi-IFC, 2024). Mejía-Escobar et al. (2021) systematically study the GB market in the region by using scientifically based econometric analysis for the first time and point out that due to an inadequate financial system and the use of just a single financial instrument, most of the LAC countries have not yet established a mature GB system. As regards the GB system, Mejía-Escobar et al. (2021) also ascertain that only one-third of LAC countries have issued GBs,

and 80% of the bonds are concentrated in Brazil, Chile and Mexico. According to Sustainable Debt Global State of the Market 2024 (CBI, 2025), Mexico is the third largest issuer of sustainable bonds in the world, with total issuance of $13 billion. Hadaś-Dyduch et al. (2022), who conduct source literature, report and statistical data analysis and employ a dynamic time wrapping methodology, point out that countries in the Central and Eastern Europe region, such as the Czech Republic, Poland, Slovakia and Hungary (the Visegrad 4 countries) are also gradually entering the GB market, and their GB issuance is more affected by inflation control and other monetary policies. This finding suggests that macroeconomic stability is a key condition for the sustainable development of green finance. Streimikiene (2024), whose analysis is based on the Green Growth Index of the Baltic States from 2010 to 2022, points out that although the geographical, political and economic conditions of the Baltic states are similar, their green growth varies, with Estonia having the highest green growth index. In addition, Kim and Laskardis (2025) map the main trends and characteristics of sovereign green, social, sustainability-linked (GSS+) sovereign bond issuance in emerging and developing countries, including Benin, Chile, Colombia, Hungary, Poland, and others. It is pointed out that the GSS+ sovereign bond market, like the ESG market, also faces the risk of "greenwashing", while the rapid expansion of GSS+ sovereign bonds has intensified investors' concerns about their authenticity and transparency. Therefore, more stringent ESG classification standards and a national policy coordination mechanism should be established, and green debt instruments should be integrated into a more systematic development strategy.

3 Methodology

This paper uses the indicators included in Table 1 for measuring SDG achievement.

As SDG indicators 7.2.1, 7.3.1, 9.4.1 (see in "SDG goals" (UN, online)) are only available from the SDG database (UN, online) until 2022 we can only analyse their relationship with green finance data for years between 2000 and 2022. The energy-related indicators serve the basis for measuring any achievement in the commitment to sustainability goals through green finance (with a correlation between the two types of variables exceeding 0.5). Green finance is approached by GB issuance data as displayed in Table 2.

Pairwise correlation is used to group countries according to their progress towards a more sustainable energy use and carbon emission where GB variables are involved together with SDG variables.

Table 1 SDG indicators used in the research (Source: UN (online))

SDG	Variable name	Indicator content	Acceptable correlation level
9	SDG 9 CO_2-to-GDP	9.4.1: Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2021 United States dollars)	< -0.5
7	SDG 7 energyint	7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 purchasing power parity GDP)	< -0.5
7	SDG 7 energyshare	7.2.1 Renewable energy share in the total final energy consumption (%)	> 0.5
7	SDG 7 renewinst	7.b.1 Installed renewable electricity-generating capacity (watts per capita)	> 0.5

Table 2 GB data included in the analysis (Source: IMF (online))

No.	GB indicator	Variable name	Explanation/data content
a	GB1	CUMGB Per-capita IMF, CBI	Dollar value of cumulative GB issuance per million people
b	GB2	CUMGBtoGDP IMF, CBI	Dollar value of cumulative GB issuance/GDP

Panel ARDL is applied so as to reveal in a dynamic setting how SGDs are related to policy commitment to achieving them. ARDL provides a methodological tool to address autoregression, endogeneity in the dataset and helps avoid spurious regressions (Ghouse et al., 2018). It can accommodate a mixture of stationary and non-stationary variables and allows for the testing of short-run and long-run effects in one single step. It can be used in an error correction setting (Kripfganz and Schneider, 2023). For this examination, in addition to SDG variables, we also included real GDP and squared real GDP data to represent the Environmental Kuznets Curve (EKC), Foreign Direct Investment to Gross Domestic Product (FDI-to-GDP) for testing for the Pollution Haven Hypothesis (PHH), trade openness as a simple sum of export and import activity, and fuel export to differentiate oil-producing economies. The variables are logarithmised and dummies represent policy changes.

4 Results

The individual pairwise correlation calculations for the 2000–2022 period revealed that in most of the countries examined cumulative GB issuance showed a strong relationship to renewable installations but only a few countries could report on improvement on all SDGs considered while increasing their GB placement in recent years. Fig. 3 reveals significant variation in how GB issuance correlates with sustainable

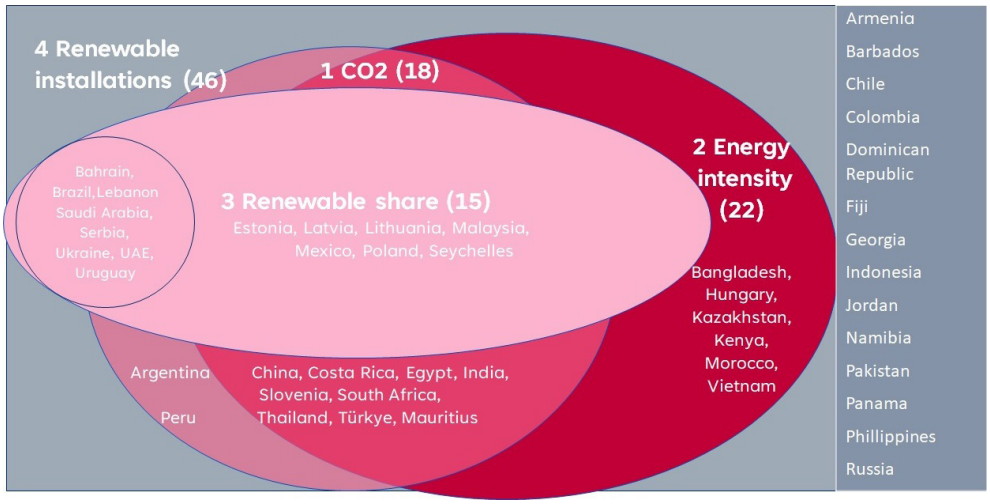

Fig. 3 Countries with acceptable correlations between SDGs and GBs (Source: Authors' owns drawing)

development outcomes across different national contexts. Countries such as China, Organization of the Petroleum Exporting Countries (OPEC) countries, the majority of Central and Eastern European Countries (CEECs) show strong positive correlations (above 0.5) between cumulative GB issuance and renewable energy installations, indicating effective combination of climate finance and commitment to real infrastructure development to promote more environmentally friendly energy solutions.

Particularly impressive are Estonia, Latvia, Lithuania, and Poland, which exhibit consistent progress across all three SDG indicators – CO_2 reduction, renewable energy share, and energy intensity improvements – suggesting that their climate finance strategies effectively tackle multiple sustainability goals simultaneously.

In contrast, some developing economies such as Bangladesh, Hungary and Vietnam show improvements in energy intensity but lag behind other nations in renewable energy share improvement, revealing uneven progress. Meanwhile, countries like Mexico, Malaysia, and Seychelles stand out for their strong performance across all correlation groupings, indicating that their GB policies might serve as valuable models for others aiming to enhance the developmental impact of sustainable finance. Calculating the correlations only for the period beginning with the entrance in the GB market we find that countries which had their first issue before 2020 mostly made progress at least in renewable installations together with their expanding presence in the GB market (apart from Colombia, Ecuador, Nigeria, Costa Rica, Morocco and Slovenia, where the latter three countries are exceptions as they only appeared in this debt market segment in one single year). Among the countries with a general improvement in SDGs, Latvia, Mexico and Poland continued improving their sustainability endeavours together with stronger presence in the GB market after entering it, Estonia and the Seychelles issued GBs in one year only and Malaysia only improved its renewable share. After their launch of the first green debt security, all the BRICS (Brazil, Russia, India, China, South Africa) economies (except Russia) plus Saudi Arabia and the United Arab Emirates showed continuously better performance across all SDG indicators. For the years after 2022 only 7.b.1 (see in "SDG goals" (UN, online)) and GB data are available and we can observe that all issuers in 2023 in the sample apart from Mongolia, Zambia (these two countries being new entrants) and Jordan (whose first issue was in 2022) continued increasing their renewable installations in 2023 as well.

Though correlation does not reveal the causal link between variables, it can well indicate a strong policy commitment to reinforcing financial markets and the environment simultaneously. Overall, these findings emphasise the need for context-specific approaches in climate finance, as comparable GB issuance levels can lead to very different sustainability outcomes depending on local policies and implementation.

It is important to note that only 54 out of the 75 countries examined had issued GBs by 2022, the end of the period under investigation (see Appendix A).

The ARDL models revealed that carbon dioxide emission is cointegrated with at least one of the other (energy-related) SDG variables and the introduction of SDG goals (represented by the SDG dummy) had a benevolent effect on the long-run dynamics of decarbonisation, marking a structural break in the period considered (note: we ran the regressions for 74 out of the 75 countries as displayed by Table 3 as Bahrain had a lot of zeros in its SDG statistics).

Our results in this simple setting reveal that renewable share has a positive effect on CO_2 emission in emerging

Table 3 Panel ARDL on CO_2 emission for 74 EMDEs

Variable	Coeff.	Std. error	t-statistic	Prob.
		Long run equation		
Energyint	0.51179	0.03485	14.7995	0.0000
Renewshare	−0.19712	0.01141	−17.2713	0.0000
Real_GDP_Capita	1.07481	0.23119	4.6490	0.0000
SQReal_GDP_Capita	−0.06457	0.01338	−4.8249	0.0000
Fuel_Exp_GDP	0.00217	0.00248	0.8745	0.3821
FDI	−0.40743	0.06036	−6.7496	0.0000
Opennes	0.06095	0.01929	3.1591	0.0016
SDG	−0.02557	0.00676	−3.7820	0.0002
		Short run equation		
Cointeq01	−0.17316	0.03084	−5.6148	0.0000
D(Energyint)	0.73325	0.05258	13.9460	0.0000
D(Renewshare)	−0.62169	0.12217	−5.0888	0.0000
D(Real_GDP_Capita)	9.27674	4.79228	1.9358	0.0532
D(SQReal_GDP_Capita)	−0.53319	0.27498	−1.9390	0.0528
D(Fuel_Exp_GDP)	−0.00707	0.00890	−0.7947	0.4270
D(FDI)	0.09239	0.07050	1.3104	0.1904
D(Opennes)	0.02282	0.01604	1.4222	0.1553
D(SDG)	0.00213	0.00679	0.3135	0.7540
C	−0.85087	0.14554	−5.8463	0.0000
RMSE*	0.02796	Mean dependent var.	−0.01086	
S.D. dependent var.	0.08346	S.E. of regression	0.03734	
Akaike info criterion	−3.89792	Sum squared residuals	1.33031	
Schwarz criterion	−1.50732	Log likelihood	4065.13	
Hannan-Quinn criterion	−3.01296			

Notes: 1 lag proved to be the best fit based on Akaike information criterion
* Root mean square error

markets as well, as has the reduction of energy intensity on the whole. We could not provide evidence for the PHH, but trade overall did seem to deteriorate carbon emission dynamics. The effect of GBs could not be justified in the overall dataset containing control countries. We can also find some evidence on the inverted U-shape behaviour of CO_2-emissions as a result of the growth in welfare, while real GDP per capita expansion seems to contribute to environmental degradation, the squared real GDP per capita variable, obtaining a significant negative sign, is meant to capture the technological change as a favourable effect on progress in carbon emissions. The per capita GDP indicators, furthermore, proved to be relevant both in the long-term and short-term dynamics of decarbonisation. Fuel export-to-GDP variable was also used as control variable as oil and gas producing economies formed a specific group in the sample significantly increasing their renewable share since the issue of EMDEs GBs gained momentum. However, this variable did not prove to be having explanatory power probably because most of the countries that are heavily reliant on fuel export revenues (Bahrain, Bolivia, Colombia, Ecuador, Gabon, Iraq, Kazakhstan, Nigeria, Russia, Saudi Arabia, United Arab Emirates, to a lesser extent Brazil, Côte d'Ivoire, Egypt, Ghana, Indonesia, Malaysia, Mexico, Mongolia and Paraguay) were either among the non-issuers or among those economies that have made a great leap forward considering renewable investment but have not been successful at emission reduction. The major exceptions are Egypt, Malaysia and Mexico in this respect as discussed above (see details in Appendix A).

We could not include the cumulative bond issuance variables in the autoregressive model setting because of the many zero values at the beginning of the period 2000–2022. Therefore, we included a "global issue" and an "emerging market issue" dummy in the dataset to examine whether the first EIB (European Investment Bank) issue in 2007 or the entrance of Panama and South

Africa as first emerging market participants in 2012 (soon followed by China, South Africa and Peru in 2014) helped achieve net-zero carbon goals. While the "global issue dummy" performed relatively well, the other representing EMDEs issue proved to be only significant with a positive sign (see Appendix B). We carried out a series of robustness checks. We ran a dynamic GMM regression to justify the effect of GB issuance on SDGs. Our results confirmed a strong relationship among SDG indicators but no such connection was found between GB and CO_2. Instead of involving real GDP per capita in the ARDL regression, Human Development Index was also used for measuring the effect of welfare and educational level on decarbonisation which are important aspects of sustainability and green growth (Barna and Szalmáné Csete, 2025; Poyraz, 2023). It consequently appeared with a negative sign in the regression and cancelled out the effect of the two bond dummies while left the SDG dummy remain significant. We also shortened the period considered by setting the starting year to 2007. However, the results of this simplification were sensitive to the lag selection applied. On the whole, the favourable effect of emerging market GBs could not unequivocally be justified in the overall dataset containing control countries.

5 Conclusions

Contrary to Alamgir and Cheng (2023) we could not provide evidence for emerging market GB issuance contributing to reduced carbon dioxide emission based on our dataset containing 75 countries and 54 GB issuers. The results of our analysis nevertheless underline that renewable energy use plays an important role in environmental improvement, GBs can have a high potential in the future as the greatest share of the use of proceeds is directed towards renewable energy investment. At the same time, the industrial structure of the global GB dataset reveals significant shortcomings in EMDEs in the field of transport and general energy supply (e.g., the modernisation of big power stations) where they are facing a serious disadvantage in the use of proceeds. Economic policy should promote these investment areas as renewables have their limitations in providing a balanced energy supply. Moreover, further research involving case studies is needed to discuss how the various country groups were able to use their financing for GBs to improve SDG compliance in the various fields of energy efficiency and harmful gas emissions.

Our findings suggest that while GBs are widely used to finance renewable energy, their actual impact on emission reduction and energy efficiency is context dependent. For example: the examination was ended in 2022 which is a serious limitation, while on the other hand, greenwashing, low environmental consciousness and/or technology level and corruption during green project implementation can also constrain the effectiveness of green projects as suggested by Kim and Laskardis (2025) among others. Policymakers in EMDEs should therefore focus on strengthening project governance, transparency, and post-issuance monitoring. Moreover, international financial institutions can use this evidence to better allocate green funds and technical assistance to maximise SDG impact. Future research could benefit from firm-level or project-level data to more precisely trace the impact of GB funding. In addition, incorporating qualitative assessments of institutional governance may help explain the heterogeneity in GB effectiveness across EMDEs.

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References

Ahmed, R., Yusuf, F., Ishaque, M. (2024) "Green bonds as a bridge to the UN sustainable development goals on environment: A climate change empirical investigation", International Journal of Finance & Economics, 29(2), pp. 2428–2451. https://doi.org/10.1002/ijfe.2787

Alamgir, M., Cheng, M.-C. (2023) "Do Green Bonds Play a Role in Achieving Sustainability?", Sustainability, 15(13), 10177. https://doi.org/10.3390/su151310177

Amundi-IFC (2022) "Riding the Green Wave: Emerging Market Green Bonds Report 2021", Amundi Asset Management and International Finance Corporation, Paris, France. [online] Available at: https://www.ifc.org/content/dam/ifc/doc/mgrt/202206-emerging-market-green-bonds-report-2021-vf-2.pdf [Accessed: 20 May 2025]

Amundi-IFC (2024) "Emerging Market Green Bonds: IFC-Amundi Joint Report", Amundi Asset Management and International Finance Corporation, Paris, France. [online] Available at: https://documents1.worldbank.org/curated/en/099734005282477873/pdf/IDU1f7d580db1e4541458918c591cb45dd4f3eb9.pdf [Accessed: 20 May 2025]

Amundi-IFC (2025) "Emerging Market Green Bonds: IFC-Amundi Joint Report", Amundi Asset Management and International Finance Corporation., Paris, France. [online] Available at: https://www.ifc.org/content/dam/ifc/doc/2025/emerging-market-green-bonds-2024.pdf [Accessed: 20 May 2025]

Barna, O., Szalmáné Csete, M. (2025) "Competence Framework-Based Assessment to Foster Sustainability Management", Periodica Polytechnica Social and Management Sciences, 33(2), pp. 166–177. https://doi.org/10.3311/PPso.22416

Bhatnagar, S., Sharma, D., Bundel, R. (2024) "Green finance and investment index for assessing scenario and performance in selected countries", World Development Sustainability, 5, 100183. https://doi.org/10.1016/j.wds.2024.100183

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., Iqbal, M. K. (2022) "Green bonds for sustainable development: Review of literature on development and impact of green bonds", Technological Forecasting and Social Change, 175, 121378. https://doi.org/10.1016/j.techfore.2021.121378

Caliari, M. (2024) "Green Bonds: Filling the Sustainable Development Goals Gap - Investigating the Role of Green Bonds in Financing the Achievement of the SDGs", MSc Thesis, Utrecht University. [online] Available at: https://studenttheses.uu.nl/handle/20.500.12932/47847 [Accessed: 20 May 2025]

CBI (2025) "Sustainable Debt Global State of the Market 2024", Climate Bonds Initiative, London, UK. [online] Available at: https://www.climatebonds.net/files/documents/publications/Climate-Bonds_Sustainable_Debt_2024_Global-State-of-the-Market_24-Sep-2025.pdf [Accessed: 20 May 2025]

CBI and CIB Research (2024) "China Sustainable Debt State of the Market Report 2023", Climate Bonds Initiative, London, UK. [online] Available at: https://www.climatebonds.net/files/documents/publications/china_sustainable_debt_state_of_the_market_report_2023.pdf [Accessed: 20 May 2025]

Das, S., Singh, P. K. (2024) "Sovereign Green Bond Issuances as A Silver-Bullet to Achieve the Sustainable Development Goals in the East and South Asian Nations", Accountancy Business and the Public Interest, 40(04), pp. 35–47. [online] Available at: https://abpi.uk/wp-content/uploads/2024/04/24V400404.pdf [Accessed: 20 May 2025]

Ezzuddin, E. (2024) "The Role of Islamic Banking and Capital Market in Promoting the Sustainable Development Goals (SDGs): The Case of Malaysia", World Scientific Annual Review of Islamic Finance, 02, 2450003. https://doi.org/10.1142/S2811023424500035

Ge, C. (2025) "An Empirical Study on the Factors Influencing the Issuance (Coupon) Rate of Green Bonds in China", International Journal of Research in Commerce and Management Studies, 7(02), pp. 68–84. https://doi.org/10.38193/IJRCMS.2025.7206

Ghouse, G., Khan, S. A., Rehman, A.U. (2018) "ARDL model as a remedy for spurious regression: problems, performance and prospectus", Munich Personal RePEc Archive (MPRA), Munich, Germany, MPRA Paper No. 83973. [online] Available at: https://mpra.ub.uni-muenchen.de/83973/1/MPRA_paper_83973.pdf [Accessed: 20 May 2025]

Hadaś-Dyduch, M., Puszer, B., Czech, M., Cichy, J. (2022) "Green Bonds as an Instrument for Financing Ecological Investments in the V4 Countries", Sustainability, 14(19), 12188. https://doi.org/10.3390/su141912188

Haddad, H. H., Rokhim, R. (2022) "The Role of Indonesian Investors in Achieving SDGs Through Green Bonds", IOP Conference Series: Earth and Environmental Science, 1111(1), 012069. https://doi.org/10.1088/1755-1315/1111/1/012069

IMF "Green bond statistics", [online] Available at: https://climate-data.imf.org/datasets/8e2772e0b65f4e33a80183ce9583d062_0/explore?appid=62c574de32334ade82ad0b85403d96d0&edit=true [Accessed: 20 May 2025]

Kim, H. R., Laskardis, C. (2025) "Sovereign Green, Social, Sustainability, and Sustainability-Linked Bonds: An Evaluation of Promises and Prospects in Developing Countries", Columbia Center on Sustainable Investment (CCSI), New York, NY, USA. https://doi.org/10.2139/ssrn.5101311

Kripfganz, S., Schneider, D. C. (2023) "ardl: Estimating autoregressive distributed lag and equilibrium correction models", The Stata Journal: Promoting Communications on Statistics and Stata, 23(4), pp. 983–1019. https://doi.org/10.1177/1536867X231212434

Lin, L., Hong, Y. (2022) "Developing a Green Bonds Market: Lessons from China", European Business Organization Law Review, 23(1), pp. 143–185. https://doi.org/10.1007/s40804-021-00231-1

Luo, X., Lyu, C. (2024) "Green Bonds Drive Environmental Performance: Evidences from China", Sustainability, 16(10), 4223. https://doi.org/10.3390/su16104223

Mejía-Escobar, J. C., González-Ruiz, J. D., Franco-Sepúlveda, G. (2021) "Current State and Development of Green Bonds Market in the Latin America and the Caribbean", Sustainability, 13(19), 10872. https://doi.org/10.3390/su131910872

Poyraz, A. Y. (2023) "Green Growth Analysis of Social Development in OECD Countries", Periodica Polytechnica Social and Management Sciences, 31(2), pp. 112–119. https://doi.org/10.3311/PPso.19995

Rao, H., Chen, D., Shen, F., Shen, Y. (2022) "Can Green Bonds Stimulate Green Innovation in Enterprises? Evidence from China", Sustainability, 14(23), 15631. https://doi.org/10.3390/su142315631

Streimikiene, D. (2024) "Assessment of Green Growth in the Baltic States", Contemporary Economics, 18(1), pp. 87–100. https://doi.org/10.5709/ce.1897-9254.527

Taghizadeh-Hesary, F., Zakari, A., Alvarado, R., Tawiah, V. (2022) "The green bond market and its use for energy efficiency finance in Africa", China Finance Review International, 12(2), pp. 241–260. https://doi.org/10.1108/CFRI-12-2021-0225

UN "SDG database", [online] Available at: https://unstats.un.org/sdgs/dataportal/database [Accessed: 20 May 2025]

UN "SDG goals", [online] Available at: https://sdgs.un.org/goals [Accessed: 20 May 2025]

Appendix A

Table A1 List of countries with significant contribution of cum GBs to SDG goals

9.4.1* CO_2 Countries with correlation < −0.5	7.b.1** Renew installation Countries with correlation > 0.5	7.2.1 Renew share Countries with correlation > 0.5	7.3.1*** Energy intensity Countries with correlation < −0.5
Argentina	Argentina	Bahrain	**Bangladesh**
China	**Armenia**	Brazil	China
Costa Rica	Bahrain	Estonia	Costa Rica
Egypt	Bangladesh	Latvia	Egypt
Estonia	**Barbados**	Lebanon	Estonia
India	Brazil	Lithuania	**Hungary**
Latvia	**Chile**	Malaysia	India
Lithuania	China	Mexico	**Kazakhstan**
Malaysia	**Colombia**	Poland	**Kenya**
Mexico	Costa Rica	Saudi Arabia	Latvia
Peru	**Dominican**	Serbia	Lithuania
Poland	Egypt	Seychelles	Malaysia
Seychelles	Estonia	Ukraine	Mexico
Slovenia	**Fiji**	United Arab Emirates	**Morocco**
South Africa	**Georgia**	Uruguay	Poland
Thailand	Hungary	(15 countries)	Seychelles
Türkiye	India		Slovenia
Mauritius	**Indonesia**		South Africa
(18 countries)	**Jordan**		Thailand
	Kazakhstan		Türkiye
	Kenya		**Vietnam**
	Latvia		Mauritius
	Lebanon		(22 countries)
	Lithuania		
	Malaysia		
	Mexico		
	Morocco		
	Namibia		
	Pakistan		
	Panama		
	Peru		
	Philippines		
	Poland		
	Russia		
	Saudi Arabia		
	Serbia		
	Seychelles		
	Slovenia		
	South Africa		
	Thailand		
	Türkiye		
	Ukraine		
	United Arab Emirates		
	Uruguay		
	Vietnam		
	Mauritius		
	(46 countries)		

* In the first column (representing indicator 9.4.1) countries that perform along all indicators well are distinguished with bold letters.
** In the second column countries which only perform in the indicator 7.b.1 as expected are indicated using bold.
*** In the fourth column countries that performed well along the indicators 7.3.1 and 7.b.1 but in no other SDGs selected are higlighted in bold.

Countries which were non-issuers in the data set can be seen in Table A1:

- Bolivia, Bosnia, Cambodia, Cabo Verde, Croatia, Gabon, Ghana, Honduras, Iraq, Kyrgyz, Maldives, Malta, Mongolia, Nepal, North Macedonia, Paraguay, Samoa, Srí Lanka, Tunisia, Uzbekistan, Zambia (21 countries) had no issues until 2023 (IFC-Amundi, 2024, IMF, online).

Among these Bolivia, Croatia, Gabon (blue bond), Malta, Mongolia, North Macedonia, Uzbekistan and Zambia issued their first green bonds in 2023, Srí Lanka in 2024. In the renewed 2025 IMF database (IMF, online) Honduras issued its first green bonds in 2016 but the Amundi-IFC (2024) did not yet consider it as issuer.

Those countries which being an issuer already and still had no relevant correlations among SDGs and GBs for the

2000–2022 period are: Ecuador, Nigeria (important fuel exporters), Côte d'Ivoire, Czech Republic, Guatemala, Romania, Slovakia (starting green bond transactions only in 2021) and Lao PDR (with first issue in 2022).

Appendix B

Dependent Variable: D(CO)
Method: ARDL
Date: 02/13/25 Time: 21:33
Sample: 2001 2022
Included observations: 1628
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): ENERGY_INT RENEW_SHARE REAL_GDP_CAPITA SQ_REAL_GDP_CAPITA FUEL_EXP_GDP FDI OPENNESS GLOBAL_ISSUE
Fixed regressors: C
Number of models evaluated: 1
Selected Model: ARDL(1, 1, 1, 1, 1, 1, 1, 1, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
ENERGY_INT	0.737161	0.027695	26.61699	0.0000
RENEW_SHARE	-0.222984	0.010448	-21.34236	0.0000
REAL_GDP_CAPITA	2.324649	0.200662	11.58492	0.0000
SQ_REAL_GDP_CAPITA	-0.135846	0.011094	-12.24445	0.0000
FUEL_EXP_GDP	-0.006212	0.001779	-3.492867	0.0005
FDI	-0.138050	0.042239	-3.268293	0.0011
OPENNESS	0.020065	0.013884	1.445171	0.1487
GLOBAL_ISSUE	-0.035764	0.004991	-7.166149	0.0000
Short Run Equation				
COINTEQ01	-0.227177	0.030923	-7.346455	0.0000
D(ENERGY_INT)	0.639871	0.052937	12.08739	0.0000
D(RENEW_SHARE)	-0.609844	0.118129	-5.162549	0.0000
D(REAL_GDP_CAPITA)	6.511693	3.224070	2.019712	0.0437
D(SQ_REAL_GDP_CAPITA)	-0.374195	0.185266	-2.019766	0.0437
D(FUEL_EXP_GDP)	-0.006014	0.007797	-0.771274	0.4407
D(FDI)	0.066364	0.070266	0.944474	0.3452
D(OPENNESS)	0.037458	0.013766	2.721058	0.0066
D(GLOBAL_ISSUE)	0.005629	0.006152	0.915030	0.3604
C	-2.576623	0.344611	-7.476897	0.0000

Root MSE	0.027525	Mean dependent var	-0.010858
S.D. dependent var	0.083461	S.E. of regression	0.036764
Akaike info criterion	-3.909749	Sum squared resid	1.289434
Schwarz criterion	-1.519155	Log likelihood	4075.196
Hannan-Quinn criter.	-3.024796		

*Note: p-values and any subsequent tests do not account for model selection.

Fig. B1 Panel ARDL on CO_2 emission for 74 EMDEs with dummy representing the start of global issues

Dependent Variable: D(CO)
Method: ARDL
Date: 02/13/25 Time: 22:12
Sample: 2001 2022
Included observations: 1628
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): ENERGY_INT FDI FUEL_EXP_GDP REAL_GDP_CAPITA SQ_REAL_GDP_CAPITA RENEW_SHARE OPENNESS EM_ISSUE
Fixed regressors: C
Number of models evaluated: 1
Selected Model: ARDL(1, 1, 1, 1, 1, 1, 1, 1, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
ENERGY_INT	0.914274	0.015989	57.18255	0.0000
FDI	-0.001243	0.008657	-0.143546	0.8859
FUEL_EXP_GDP	0.003499	0.001664	2.103011	0.0357
REAL_GDP_CAPITA	0.971804	0.121586	7.992741	0.0000
SQ_REAL_GDP_CAPITA	-0.060827	0.006872	-8.851982	0.0000
RENEW_SHARE	-0.169954	0.008547	-19.88393	0.0000
OPENNESS	0.018837	0.006819	2.762543	0.0058
EM_ISSUE	0.015011	0.002052	7.316411	0.0000
Short Run Equation				
COINTEQ01	-0.270310	0.037508	-7.206826	0.0000
D(ENERGY_INT)	0.596158	0.056834	10.48946	0.0000
D(FDI)	0.068579	0.075338	0.910283	0.3629
D(FUEL_EXP_GDP)	-0.006123	0.006696	-0.914291	0.3608
D(REAL_GDP_CAPITA)	4.826121	2.999025	1.609230	0.1079
D(SQ_REAL_GDP_CAPITA)	-0.270080	0.174879	-1.544385	0.1228
D(RENEW_SHARE)	-0.586487	0.117247	-5.002128	0.0000
D(OPENNESS)	0.021565	0.015509	1.390416	0.1647
D(EM_ISSUE)	0.005066	0.004725	1.072212	0.2839
C	-1.678484	0.224761	-7.467855	0.0000

Root MSE	0.028082	Mean dependent var	-0.010858
S.D. dependent var	0.083461	S.E. of regression	0.037508
Akaike info criterion	-3.886006	Sum squared resid	1.342156
Schwarz criterion	-1.495413	Log likelihood	4054.991
Hannan-Quinn criter.	-3.001053		

*Note: p-values and any subsequent tests do not account for model selection.

Fig. B2 Panel ARDL on CO_2 emission for 74 EMDEs with dummy representing the start of emerging market issues

Both dummies ("global issue" (Fig. B1) and "EMDE issue" (Fig. B2)) increased the error correction term's coefficient (the speed of adjustment) and significantly impacted the coefficient for the FDI, openness and fuel export, with the latter changing its sign in the various model specifications.