BIS Economics and Business

Volume 3 2026 | DOI: 10.31603/biseb.554
7th Borobudur International Symposium on Humanities and Social Science (BIS-HSS) 2025

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Regional integration and renewable energy transition for sustainable development in belt and road initiative countries

Fadhilal Ahmad[1], Cut Risya Varlitya[1*], and Muhammad Ilhamsyah Siregar[1]

[1] University Syiah Kuala, Banda Aceh, Indonesia
[*]Corresponding author's email: cutrisyavarlitya@usk.ac.id

Abstract

This study examines how renewable energy transition, regional integration, government size, and current account balance affect sustainable development in 52 Belt and Road countries (2006–2021). Using Two-Step System GMM, it finds that renewable energy transition and government size are insignificant, while regional integration positively impacts sustainability when coupled with economic growth, and current account balance also has a positive effect. These results guide policymakers in promoting clean energy, regional cooperation, and effective governance for long-term sustainability.

Keywords

Regional integration, Renewable energy transition, Sustainable development, Belt and road initiative, Government size, Current account balance

Introduction

The combustion of fossil fuels, which intensifies climate change, represents one of the most pressing global challenges today. As a result, the world is now 1.2 degrees Celsius warmer than preindustrial times. This has dire consequences, including a rise in the sea level, extreme weather, and compromised food and water security [1][2]. One of the mechanisms designed to counter these multi-dimensional threats is the 2030 agenda on sustainable development, specifically its 7th goal on the right of every person to access clean, affordable, and dependable energy, a precondition to all other development [3]. However, lack of investments in renewable energy has led to a persistent dependency on fossil energy and a continued disparity in energy access - challenges that are most dire in the developing world [4] [5].

The shift to renewable energy is now recognized by many scholars and policymakers as an important factor in reducing emissions and threats to energy security as well as in

Published:
May 04, 2026

Selection and Peer-review under the responsibility of the 7th BIS-HSS 2025 Committee

fostering sustained, long-term development [6][7]. Recent research studies point to its importance in achieving green growth and opening decarbonization pathways in affluent and poor nations [8] [9]. In this context, regional integration is considered a potentially supportive mechanism. It can expedite the diffusion of green technologies, scale-up cross-border investments and implement cooperative approaches to deal with the environment [10]. However, its potential is limited to the host nation's economic capacity and structural readiness.

Apart from energy and integration, the macroeconomics of a nation also determine how or to what extent sustainable development is achievable. The size of government, defined in this case as public expenditures relative to GDP, can promote sustainability through efficiency in resource allocation, but excessive government expansion may reduce policy efficiency and generate resource misallocation [11] [12]. In the same way, a current account surplus indicative of external financial stability and fiscal capacity is a precondition for long-term green investments [13] [14].

Despite the growing literature on renewable energy transition and sustainable development, empirical findings remain inconclusive, particularly for developing and emerging economies. Some studies report positive sustainability effects, while others find insignificant or even adverse impacts due to institutional weaknesses and structural constraints. Moreover, limited research simultaneously examines the interaction between renewable energy transition and regional integration within the Belt and Road Initiative (BRI) framework. The role of macroeconomic stability, especially current account balance and government size, in shaping sustainable development outcomes in BRI countries also remains underexplored. Therefore, this study addresses this gap by investigating the dynamic and interactive effects of renewable energy transition, regional integration, government size, and current account balance on sustainable development in 52 BRI countries.

To address this gap, the present study examines the dynamic effects of renewable energy transition, regional integration, government size, and current account balance on sustainable development in 52 BRI countries over the period 2006–2021. The BRI is an appropriate empirical setting not only due to its significant share of global carbon emissions, as its cross-regional connectivity objectives provide a foundation for long-term renewable energy deployment and infrastructure development [15][16][17]. Using a dynamic panel approach via Two-Step System Generalized Method of Moments (GMM), this study provides robust empirical evidence that these interconnected components as a whole affect sustainable development outcomes, particularly in the former's mediatory effects on renewable energy and green infrastructure investments, in the context of BRI [18]. Specifically, this study aims to: (1) identify the effects of regional integration on trade and FDI flows; (2) examine the influence of renewable energy transition; (3) assess the role of government size; (4) evaluate the impact of current account balance on sustainable development.

This study contributes to the literature in three main ways. First, it focuses specifically on BRI countries, which represent a major share of global emissions but remain underexamined in sustainability-transition studies. Second, it introduces the interaction term between regional integration and economic growth to capture conditional integration effects on sustainable development. Third, it incorporates macroeconomic stability variables, particularly current account balance, into the sustainability framework using a dynamic panel Two-Step System GMM approach.

Method

This study examines the effects of renewable energy transition, regional integration, government size, and current account balance on sustainable development in 52 BRI countries from 2006 to 2021. Sustainable development is proxied by Adjusted Net Savings. Renewable energy transition is proxied by per capita renewable energy consumption. Regional integration is measured using the Multidimensional Regional Integration Index (MRII). Government size is represented by the ratio of government expenditure to GDP, while macroeconomic stability is captured through the current account balance. To capture the effect of economic growth, control and MEUI integration variables, an interaction term between regional integration and economic growth (MRII × EG) is included to capture conditional integration effects.

In this section, country-specific heterogeneity, endogeneity, and simultaneity bias are addressed using the two-step system Generalized Method of Moments (GMM) estimator. The dynamic panel specification allows for the inclusion of lagged dependent variables and appropriate internal instruments, ensuring consistent and efficient estimation. The general panel specification is demonstrated as follows [8]:

$$SD_{it} = \propto + \lambda SDi_{,t} - 1 + \beta 1\ RET_{it} + \beta 2\ MRII_{it} + \beta 3\ GS_{it} + \beta 4\ CAB_{it} + \beta 5\ EG_{it} + \beta 6\ (MRII_{it}\ x\ EG_{it}) + \varphi_{it} + \varepsilon_{it}$$

The equation states that sustainable development SDit is a function of its lagged form $SD_{i,t-1}$, renewable energy transition RET_{it}, regional integration $MRII_{it}$, government size GS_{it}, current account balance CAB_{it}, economic growth EG_{it}, and the interaction of regional integration and economic growth ($MRII_{it} \times EG_{it}$). Here, SDit stands for sustainable development for country i at time t, and α for the constant. The value of λ shows the persistence of sustainable development across time through the lagged dependent variable $SD_{i,t-1}$. The variables RET_{it}, $MRII_{it}$, GS_{it}, CAB_{it}, and EG_{it} show the values for renewable energy transition, regional integration, government size, current account balance, and economic growth, respectively, for country i and time t. The interaction of regional integration and economic growth ($MRII_{it} \times EG_{it}$) shows the combined effect of regional integration and economic growth on sustainable development. The coefficients β show the marginal change for the independent variables. Additionally, φi shows the country-specific effects that remain constant through time, and εit shows the error term that varies by country and time.

Instrument validity is examined using the Sargan and Hansen tests, while serial correlation is assessed through the Arellano–Bond AR(1) and AR(2) tests. The long-run effect is calculated with the formula β/(1−γ), with γ as the coefficient of the lagged dependent variable.

Results and discussion

Results

The Two-Step System GMM estimator is employed to estimate the dynamic panel relationships using lagged internal instruments. The xtdpdsys command in Stata is utilized to address endogeneity, simultaneity, and unobserved heterogeneity. The results from the short-term regressions are summarized in Table 1, which contains the coefficients and significance of the independent variables.

Table 1. Result of the two-step system GMM regression

sd	Coefficient	Std.err.	z	P>|z|	[95% conf. interval]
L.SD	0.6899224	0.0147944	46.63	0.000	0.660926 0.7189188
EG	-0.3461308	0.0467442	-7.40	0.000	-0.4377479 -0.2545138
RET	0.0255534	0.0146566	1.74	0.081	-0.003173 0.0542798
MRII	-5.225666	2.003505	-2.61	0.009	-9.152463 -1.298868
GS	-0.0907602	0.0510617	-1.78	0.075	-0.1908393 0.0093189
CAB	0.211575	0.0126736	16.69	0.000	0.1867351 0.2364148
MRIIEG	1.061903	0.0924776	11.48	0.000	0.8806501 1.243155
_CONS	5.900662	1.539312	3.83	0.000	2.883666 8.917659

The Sargan test confirms instrument validity ($\chi^2 = 43.6347$, $p = 1.0000$), the presence of first-order autocorrelation (AR(1)) and the absence of second-order autocorrelation (AR(2)) confirm the validity of the Arellano–Bond test for dynamic consistency, thereby satisfying GMM assumptions. The validity was cross-checked with the estimates from FD-GMM, System GMM, FEM, and PLS (Table 2), showing that FD-GMM was the most unbiased reflective estimator considering the properties of the data.

Table 2. Result of the unbiased test regression

Variable	fdgmm	sysgmm	fem	pls
L.SD	0.60165721***	0.6899224***	0.61218607***	0.8922135***
EG	-0.14781178***	-0.34613081***	-0.07508148	-0.03184963
RET	-0.00282079	0.0255534	-0.1129037***	0.00188363
MRII	-15.339366***	-5.2256656***	-14.038702**	-0.58081226
GS	-0.10697082	-0.09076024	-0.29556797***	-0.00752196
CAB	0.21252464***	0.21157498***	0.1659312***	0.10676613***
MRIIEG	0.68287528***	1.0619028***	0.52979509**	0.42658728*
_CONS	12.357288***	5.9006624***	17.305441***	0.88260932
N	725	778	778	778

Legend: *p<0.05; **p<0.01; ***p<0.001

Based on these estimations, long-run coefficients are calculated using the formula β/(1 − γ), where γ represents the coefficient of the lagged dependent variable. These long-term results (Table 3) give a broader picture of the overall impact over time of

renewable energy transition, regional integration, government size, and current account balance on sustainable development.

Table 3. Result of the long-term regression

sd	Coefficient	Std.err.	z	P>|z|	[95% conf. interval]
_nl_1	0.0824097	0.0475963	1.73	0.083	-0.0108773 0.1756967
_nl_2	-16.85277	6.057717	-2.78	0.005	-28.72567 -4.97986
_nl_3	-0.2927017	0.1632126	-1.79	0.073	-0.6125925 0.0271891
_nl_4	0.6823291	0.0529169	12.89	0.000	0.5786139 0.7860444
_nl_5	3.424636	0.3468562	9.87	0.000	2.74481 4.104461

Discussion

The Two-Step System GMM results show that renewable energy transition (RET) has a positive but nonsignificant influence on SD in BRI countries, both in the short and long run. These findings suggest that both short-run and long-run effects of renewable energy transition remain limited. Although this finding contradicts both Green Growth and Multi-Level Perspective (MLP) theories, which posit that the use of clean energy sources should increase sustainability, a number of other empirical studies have reported no or negative effects of renewable energy on economic and sustainability impacts, particularly in developing and emerging economies [19] [20] [21]. The persistence of these null results with regard to the time dimension suggests that the sustainability gains arising from renewable energy transition need more solid institutional preferences, technological preparedness, and policy coherence in order to be achieved.

The GMM results indicate that regional integration (MRII) exerts a negative and statistically significant direct effect on sustainable development in both the short and long run. However, when regional integration is interacted with economic growth (MRII×EG), the sign of this coefficient turns positive and significant in both horizons. This finding implies that regional integration contributes to sustainable development only when supported by sufficient domestic economic capacity. These results support Neofunctionalism, with functional spillover effects across sectors playing a significant role, and Intergovernmentalism, which emphasizes that national governments play a critical role in integration outcomes [22] [23]. They are also consistent with existing empirical evidence that the benefits of regionalization for sustainability outcomes are contingent on economic development [24].

The coefficients of government size (GS) are negative but not statistically significant in both SR and LR, suggesting that a bigger government does not necessarily lead to a better SD. This finding aligns with Public Choice theory, which argues that excessive government expansion may lead to bureaucratic inefficiency and rent-seeking behavior. It is also consistent with the Inverted-U Government Size Hypothesis, which suggests that government expansion supports green growth and innovation only up to an optimal level, beyond which marginal returns begin to decline [25].

By contrast, the current account balance (CAB) has a positive, significant and robust impact on sustainable development in both short and long run. This finding indicates that having a stable and surplus position externally could increase financial capacity of a country to finance short-term and long-term investments in green infrastructure and clean energy. The result supports macroeconomic theory and the savings growth–investment squeeze identity [26] as well as with Sustainable Development and Green Growth perspectives, which emphasize that external balance contributes to more efficient resource allocation to achieve social, economic and environmental sustainability [27] [28] [8].

Overall, sustainable development in BRI countries is shaped by the interaction between renewable energy transition (RET), regional integration (MRII), government size (GS), and current account balance (CAB). While RET and GS exhibit limited or statistically insignificant effects in both the short and long run, CAB demonstrates a consistently positive and significant impact. Moreover, regional integration contributes positively to sustainable development only when supported by sufficient economic growth. These findings carry important implications for policymakers in fuel-exporting and developing economies.

Conclusion

The paper investigates the impact of renewable energy transition, regional integration, government size and current account balance on sustainable development in 52 Belt and Road Initiative countries from 2006 to 2021 with a Two-Step System GMM approach. The findings indicate that renewable energy transition does not exert a statistically significant impact on sustainable development in either the short or long run. The results indicate that regional integration presents a negative direct effect but a positive and significant interaction with economic growth, regional integration presents a negative direct effect but a positive and significant interaction with economic growth, meaning that the integration is only beneficial for sustainability when it takes place with an appropriate local economic capability. Government size exhibits a negative but statistically insignificant effect on sustainable development.

A number of policy implications can be drawn from these findings. For one, BRI countries should fast-track the deployment of renewable energy by enhancing green financing means, improving institutional quality, and strengthening technological readiness to better ensure that investments in renewable energy really lead to meaningful sustainability benefits. Second, regional integration endeavors should be complemented by domestic policies that maximize the spillovers from integration by local firms to foster economic growth and productive capacity. In the third place, instead of enlarging the size of government, it is necessary for governments to focus on efficiency and quality of public expenditure by investing more in sustainable infrastructure and clean energy. Lastly, macroeconomic stability and a sound current account balance are key to the sustainability of long-term finance for sustainable

development and green growth. These results demonstrate that sustainable development is shaped by the interaction between energy transition, regional integration, government capacity, and macroeconomic stability.

Acknowledgement

The authors would like to acknowledge the Faculty of Economics and Business, Universitas Syiah Kuala (FEB USK) for providing academic support and facilities in preparation and accomplishing this research. The author also thanks all the members of FEB USK who provided helpful input and support to enhance the quality of this research.

References

1. IPCC *Global Warming of 1.5°C*; 2018; ISBN 9781009157940.
2. Luderer, G.; Vrontisi, Z.; Bertram, C.; Edelenbosch, O.Y.; Pietzcker, R.C.; Rogelj, J.; De Boer, H.S.; Drouet, L.; Emmerling, J.; Fricko, O.; et al. Residual Fossil CO2 Emissions in 1.5-2 °c Pathways. *Nat. Clim. Chang.* 2018, *8*, 626–633, doi:10.1038/s41558-018-0198-6.
3. United Nations Transforming Our World: The 2030 Agenda for Sustainable Development.
4. UN Ensuring Access to Affordable, Reliable, Sustainable and Modern Energy. 2019, 22559.
5. IEA World Energy Outlook 2019 —. *World Energy Outlook 2019* 2019, 1.
6. Berrill, P.; Arvesen, A.; Scholz, Y.; Gils, H.C.; Hertwich, E.G. Environmental Impacts of High Penetration Renewable Energy Scenarios for Europe. *Environ. Res. Lett.* 2016, *11*, doi:10.1088/1748-9326/11/1/014012.
7. Hansen, K.; Mathiesen, B.V.; Skov, I.R. Full Energy System Transition towards 100% Renewable Energy in Germany in 2050. *Renew. Sustain. Energy Rev.* 2019, *102*, 1–13, doi:10.1016/j.rser.2018.11.038.
8. Ullah, A.; Nobanee, H.; Ullah, S.; Iftikhar, H. Renewable Energy Transition and Regional Integration: Energizing the Pathway to Sustainable Development. *Energy Policy* 2024, *193*, 114270, doi:10.1016/j.enpol.2024.114270.
9. Dradra, Z. Do Energy Transition and Environmental Taxation Contribute to Sustainable Development ? Evidence from OECD Countries. 2025, doi:10.1108/AGJSR-05-2023-0195.
10. Huh, H.S.; Park, C.Y. Asia-Pacific Regional Integration Index: Construction, Interpretation, and Comparison. *J. Asian Econ.* 2018, *54*, 22–38, doi:10.1016/j.asieco.2017.12.001.
11. Goh, H.; Syawal, M.; Mohd, B. The Optimal Government Size and Economic Growth : A Comparative Study between Malaysia and South Korea. *Heliyon* 2023, *9*, e22834, doi:10.1016/j.heliyon.2023.e22834.
12. Abdillah, K. Optimum Government Size and Economic Growth in Indonesia : ARDL Model Approach. 2023, *18*, 37–47.
13. Monamodi, N.E. The Impact of Current Account Balance on Economic Growth in South Africa. 2024.
14. Altayligil, Y.B.; Çetrez, M. Macroeconomic , Institutional and Financial Determinants of Current Account Balances : A Panel Data Assessment. *J. Econ. Struct.* 2020, 1–23, doi:10.1186/s40008-020-00225-1.
15. Hou, X.; Shao, C.; Wang, X.; Zhang, Q. Environmental Effects of the Belt and Road Initiative: Evidence from Countries along the Belt and Road. *Transp. Res. Part D Transp. Environ.* 2020, *81*.
16. Dunford, M.; Liu, W. The Belt and Road Initiative. *Int. Encycl. Geogr.* 2020, 1–10, doi:10.1002/9781118786352.wbieg2020.
17. Rauf, A.; Liu, X.; Amin, W.; Rehman, O.U.; Li, J.; Ahmad, F.; Victor Bekun, F. Does Sustainable Growth, Energy Consumption and Environment Challenges Matter for Belt and Road Initiative Feat? A Novel Empirical Investigation. *J. Clean. Prod.* 2020, *262*, 121344, doi:10.1016/j.jclepro.2020.121344.
18. Gatto, A.; Drago, C.; Panarello, D.; Aldieri, L. Energy Transition in China: Assessing Progress in Sustainable Development and Resilience Directions. *Int. Econ.* 2023, *176*, 100450, doi:10.1016/j.inteco.2023.08.001.
19. Dirma, V.; Neverauskien, L.O. ¯ut˙e; Tvaronavi˘cien, M.; Danilevi˘cien, I.; ¯unien˙e, R.T. The Impact of Renewable Energy Development on Economic Growth. 2024.
20. Feng, Y.; Zhao, T. Exploring the Nonlinear Relationship between Renewable Energy Consumption and Economic Growth in the Context of Global Climate Change. 2022.

21. Asmawati, T.; Hidayat, M.; Murialti, N. Analysis of Government Expenditure and Investment in Reducing Unemployment Between Regions of The Island Of Sumatra with Fd-Gmm And Sys-Gmm Methods. 2025, *8*, 756–768.
22. Pomerlyan, E.; Belitski, M. Integration - Growth Relationship: A Literature Review and Future Research Agenda Using a TCCM Approach. *Eur. Manag. J.* 2023, *41*, 1106–1118, doi:10.1016/j.emj.2023.10.003.
23. Börzel, T.A.; Risse, T. Grand Theories of Integration and the Challenges of Comparative Regionalism. *J. Eur. Public Policy* 2019, *26*, 1231–1252, doi:10.1080/13501763.2019.1622589.
24. Wu, J.; Sun, W. Regional Integration and Sustainable Development in the Yangtze River Delta , China : Towards a Conceptual Framework. 2023.
25. Syawal, M.; Mohd, B.; Goh, H.; Koong, S.; Tan, S. Heliyon Nonlinear Threshold Approach for Asymmetric Effects of Government Size on Economic Growth in an Emerging Asian Economy : The Malaysian Experience. *Heliyon* 2022, *8*, e10524, doi:10.1016/j.heliyon.2022.e10524.
26. Edwards, S. Thirty Years of Current Account Imbalances, Current Account Reversals, and Sudden Stops. 2004, *51*, 1–49.
27. Sachs, J.D. *The Age of Sustainable Development*; 2015;
28. Grossman, G. M., & Krueger, A.B. Economic Growth and the Environment. *Q. J. Econ.* 1995, 353–377.