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Sustainable growth strategy promoting green innovation processes, mass production, and climate change adaptation: A win-win situation

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Introduction

The shift from the linear to the circular model is primarily facilitated by sustainability practices, which create new networks and offers choices in product manufacturing, environmental management, and after-sale functions—demonstrating that eco-friendly technological advancement is essential to the development of circular economies. Therefore, businesses of all sizes need to think about green process innovation (Awan et al., 2022; Awan and Sroufe, 2022; Zaman et al., 2022). The global economy and the environment are both affected by climate change. Unpredictable weather conditions and a rise in temperature of around 0.8°C pose problems for Indonesia's agricultural sector (Oktaviani et al., 2011). The global economic climate is challenging, and the pandemic threat to Indonesia is considerable. Domestic demand and the private sector, notably SMEs and microenterprises, were hit severely by the epidemic of COVID-19, as were the effects of rising inflation, harsh weather, and the government's efforts to stimulate the economy (World Bank, 2022a). As USAID (2022) reported, millions of Indonesians rely on the country's natural resources for their daily needs and economic well-being. The country's growth is being hampered by climate change and extreme weather events, including cyclones, floods, landslides, droughts, and earthquakes. From Gunawan et al. (2022) Analysis of sensitive and non-sensitive Indonesian sectors across economic, social, and environmental dimensions revealed a consistent upward trend in sustainability over time. The economic complexity index for environmental

sustainability in Indonesia, as reported by Chandrarin et al. (2022), predicts that a combination of GDP growth, economic complexity, and technological advancements in the natural resource sectors will drastically cut carbon emissions and subsequent climate change. Sustainable development strategy has a significant impact on changing climatic circumstances, suggesting the need for a framework of regulations to minimize emissions in order to save the environment and human civilization.

Sustainability in Indonesia's economy is boosted by the country's sectors' economic expansion and the stifling of energy development. Indonesia's economy is very vulnerable to floods and harsh heat, as reported by the member nation partnership strategy, due to the country's unpredictable climatic experiences with rapidly increasing temperatures and monsoonal rainfall patterns. Water and food security, urban growth (especially in coastal zones), and catastrophe risk management all suffer due to climate change's unpredictability, which exacerbates poverty and inequality. Climate change poses a significant threat to the execution of the Sustainable Development Goals and the 2030 Agenda for Global Goals because of its potential impact on the availability of funds for these goals. Building a circular social economy at the company level depends on the broader practises of the social logistics system, such as occupational risks and eco-labelling (Awan, 2019a). Knowledge transmission between consumers and businesses may be optimized in a community with a strong emphasis on cultural sensitivity (Awan, 2019b). An organization's social performance and outcomes may be influenced by its intercultural competence, which can increase its ability to recognize social dynamics, seize and adapt internationally disseminated traditional norms on new issues, and generate extensive information resources and skills (Awan et al., 2018). Potentially considerable societal benefits are a significant motivator for innovative activity (Awan and Sroufe, 2020).

The necessity for the study is to offer sustainable policies for the Indonesian economy, which has been adversely impacted by the tremendous growth in the world carbon emissions, large-scale unsustainable manufacturing, increased population pressure, and international research and development on unsustainable innovation, which has caused the globe to become warmer. Accordingly, the study's contribution is to evaluate all the stated factors in the Indonesian economy, which have been comparatively little investigated in the past. For instance, previous research has primarily focused on exploring the role of economic growth on carbon emissions, substantiating the hump-shaped relationship between the variables (Salman et al., 2019; Bashir et al., 2021; Massagony and Budiono, 2022). However, it has less to explore the impact of global carbon emissions on Indonesian economic growth, which was incorporated into the study to get robust policy inferences. Second, the previous studies used various sectors and their contribution to GDP in pollution damage functions (Zaman et al., 2017; Batool et al., 2019; Khan et al., 2019). However, they were less likely to investigate large-scale manufacturing on country-specific factors that were incorporated into the study in the context of the Indonesian economy. Finally, the global rise in population pressure and enormous spending on R&D further threaten the environment, ultimately affecting the country's economic growth, a topic less explored in the earlier literature (Anser et al., 2022; Kilinc-Ata and Castanho, 2022). This finding is a step forward in the research into sustainable economic growth.

Research questions

Three research questions guide this investigation:

1. Is Indonesia's economy vulnerable to a global spike in carbon emissions caused by rising industrial value added?
2. How does an increasing global population drain a country's resources, making it hard to conserve them?
3. Whether foreign R&D expenditure would lead to the transfer of technology to rising economies such as Indonesia?

Research objectives

The study investigated the following research objectives:

I. To investigate the impact of rising global carbon emissions on Indonesian economic growth.
II. To examine the strain of enormous increase in the world's population growth on the country's economic objectives.
III. To determine the role of the massive increase in the manufacturing value added due to a rise in the world's innovation capabilities on the country's financial viability, and
IV. To explore the causal and inter-temporal relationships between the stated variables.

Materials and methods

Data source and variables identification

The study used the time series data for the years 1980–2020 from the World Bank (2022b) database. The study used the Indonesian GDP per capita (constant 2015 US$)

TABLE 1 RLS estimates, granger causality and VDA estimates.

Robust MM-Regression estimates: Dependent variable: ln(GDPPC)

Variables	Coefficient	Standard error	*t*-statistics	Prob. value	Decision
ln (GDPPC)t-1	1.103	0.026	41.458	0.000	Significant at 5%
ln (WCO2)	−0.071	0.023	−2.990	0.002	Significant at 5%
ln (WMVAD)	0.086	0.080	1.076	0.281	Insignificant
ln (WPOP)	−0.134	0.058	−2.295	0.021	Significant at 5%
ln (WR&D)	−0.096	0.035	−.711	0.006	Significant at1%
Statistical and Diagnostic Tests					
R2	0.781	Adjusted R2	0.749	RW2	0.999
Heteroskedasticity Test	1.388 (0.229)	Serial Correlation LM Test (F-statistics)	1.736 (0.923)	Ramsey RESET Test	0.106 (0.236)
Granger Causality Test Estimates					
ln (WMVAD)↔ ln (WCO2)	ln (WPOP)→ ln (GDPPC)	ln(WPOP)→ ln (WMVAD)	ln (WPOP)↔ ln (WCO2)	ln (WMVAD)→ ln (GDPPC)	ln (WR&D)→ ln (WCO2)
Variance Decomposition Analysis (VDA) Estimates					
2022–2031	WCO2 influenced 2.271% of GDPPC	WMVD influenced 14.222% of GDPPC	WPOP influenced 0.502% of GDPPC	WR&D influenced 71.436% of GDPPC	

(denoted by GDPPC) as a response variable, while the list of regressors is as follows:

I. Global carbon emissions (in metric tonnes per person; WCO2),
II. World population (total population; WPOP,
III. Large-scale manufacturing value-added (in percentage terms of GDP; WMVAD), and
IV. International research and development expenditures (as a % of GDP; WR&D).

Methodology

The investigation used the robust least squares (RLS) regression approach, which yielded Eq. 1. For the RLS analysis, we first determined how much the variables varied from their actual regression line by examining the leverage plots of the regresses.

$$\ln(GDPPC)_t = \alpha_1 + \alpha_2 \ln(GDPPC)_{t-1} + \alpha_2 \ln(WCO2)_t$$

$$+\alpha_3 \ln(WPOP)_t + \alpha_4 \ln(WMVAD)_t + \alpha_5 \ln(WR\&D)_t + \varepsilon \quad (1)$$

Where, ln shows natural logarithm, 't' shows time period, and ε shows error term.

In the second phase, the study looked at four robust statistics (i.e., RStudent, Hat Matrix, DFFITS, and COVRATIO) to find outliers in the data. Once stated tests have been analyzed, the study may go on to use the RLS regression, which has three different estimating processes, i.e.,

i. M- Estimator
ii. S- Estimator
iii. MM- Estimator

Huber (1973) proposed using M-estimation analyses as part of the RLS regression approach to look for likely outliers in the dependent variable by locating large residuals. Rousseeuw and Yohai, (1984) suggested using the S-estimation procedure inside the RLS approach to detect outliers in the regressors and filter high leverages. Finally, Yohai (1987) proposed the S- and M-estimator combination (MM- estimator) to deal with potential outliers across all datasets. As a result, the outlier variables in the datasets were isolated, and the residuals and leverage were reduced.

Results and discussion

Identifying and characterizing any potential outliers in the research variables is vital before attempting an RLS regression approach estimate. Leverage plots revealed that the estimated values of the variables under study were more widely dispersed than anticipated, indicating the presence of probable outliers. In light of this, the straightforward OLS method is unsuitable for variable estimation. The results of influence statistics for the best selection of estimators reveal that one outlier was discovered in an R student, while DFFIT and the Hat matrix each identified two outliers, and COVRATIO suggested that three probable outliers exist in the Model. In order to validate the presence of outliers in the dependent and independent variables, we used the

MM estimation of robust regression approach, which provides significant results and accounts for all potential outliers.

The descriptive data reveal a mean value of US$2229.941 for Indonesia's GDP per capita, a minimum value of US$1129.182, the highest value of US$3877.425, and a standard deviation value of US$855.7738. Global carbon emissions have a minimum value of 206,252 metric tonnes per capita, a maximum value of 34,344,006 metric tonnes per capita, a mean value of 2,536,041 metric tonnes per capita, a positive skewness, and a low Kurtosis value. The total global population is estimated to be 6.10E+09, large-scale industrial value added is estimated to be 13.845% of GDP, and worldwide R&D expenditure is estimated to be 2.025% of GDP.

According to the RLS MM-regression estimator in Table 1, global factors like carbon emissions, technical progress favouring the affluent, and rapid population increase hurt Indonesia's economy. Therefore, it is crucial to go ahead with COP26's aim of reducing carbon emissions *via* mutual scientific cooperation, technological transfer, information spillover, and restricting population expansion, all of which assist the Indonesian economy in developing economic success. Sugiawan et al. (2022), Wen et al. (2022), and Heryadi and Hartono (2017) were all findings that were compatible with the result. In order to meet ambitious goals for cutting carbon emissions, these studies advocate boosting energy efficiency in the production and consumption sectors, decreasing reliance on fossil fuels, and maximising the effectiveness of renewable resources. To optimize economic output through an increase in GDP per capita and energy savings, an energy efficiency policy should be implemented with an efficient distribution of energy subsidies, particularly in the industrial sector (Hanif et al., 2022). In order to raise efficiency, it is necessary to improve the quality of the environmental regulations and to encourage research and development in all sectors. In addition, increasing international cooperation and R&D spending in high-productivity industries to raise output and boost the economy is vital for sustained development (Afshan et al., 2022).

Multiple diagnostic tools were used in the model, all of which confirmed the model's validity. The Granger causality test was run after diagnostic tests showed a positive result. It verified the feedback connection between industrial production and carbon emissions, and between population increase and carbon output. Additionally, the Granger test confirmed the contributions of population increase to economic growth and manufacturing production, R&D to carbon emissions, and manufacturing to GDP growth. According to VDA projections, foreign R&D expenditures are the factor most likely to affect the country's economic development, with a variance shock of 71.436%, followed by large-scale industrial output and global carbon emissions. Increases in global population during the next decade will have the slightest impact on economic growth, with a variance of about 0.502%.

Conclusion

Sustainable development is an ambitious goal that requires a multifaceted approach to getting from where we are now to where we need to be. Strategies to alter firms' activities across sectors include adapting green processes, renewable energy, and intensifying green innovation. Indonesia's economy is impacted by global emissions and needs scientific-technical cooperation to develop. The findings demonstrate that the massive industrialization, technical development, and growing world population growth are linked to a significant rise in global carbon emissions, reducing economic output in Indonesia. The causal estimates confirmed the bidirectional link between manufacturing output and carbon emissions. A unidirectional causality was found from population growth to economic growth and manufacturing output. Technological advancement and manufacturing output Granger cause economic growth and carbon emissions, respectively. According to the projections, technical progress significantly impacts economic development in Indonesia.

The earth's climate and other forms of environmental degradation have become more pressing problems as the world economy has expanded rapidly. Instead of trying to alleviate environmental strain, measures aimed at bolstering the Indonesian economy should concentrate on improving technology, boosting innovation, and optimizing the structure of various industries. Advocate for and engage in policy discourse to help regional members craft population policies that align with their broader development objectives and get widespread support from their respective populations. Improving the coverage and quality of reproductive health services, among other programmes, will need a concerted effort to expand regional members' institutional capacity. Investing in R&D only leads to increased economic growth when the ability to bridge the gap between technical advancement and subsequent innovation and expansion. Hence, the Indonesian economy is anticipated to advance and develop technological competence, leading to economic success.

Indonesia's goal is to break out of the economic stagnation that characterizes middle-income countries. Dependence on coal-fired power plants poses the greatest difficulty for the nation. International collaboration, advanced technology, commercial viability, and international investment will be needed to facilitate the energy shift from coal plants to renewables. Thus, with the

help of all economic actors, a thriving state ecology may be established. A policy package that provides strong signals to international businesses is necessary for Indonesia to realize its ambition of greater prosperity and sustainable development. The Government should keep a close eye on the year's progress and accomplishments in reducing GHG emissions in compliance with Indonesia's decarbonization goal set by the UNFCCC. The study is limited to a single country and uses a few vital factors. In further research, it may be possible to extend it to a panel of developing countries, improving the study's generalized capacity. In order to arrive at accurate conclusions from growth modeling, other factors, such as technical advancement, financial expansion, and environmental legislation, might be included.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://databank.worldbank.org/source/world-development-indicators.

Author conftributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Afshan, S., Ozturk, I., and Yaqoob, T. (2022). Facilitating renewable energy transition, ecological innovations and stringent environmental policies to improve ecological sustainability: Evidence from MM-QR method. *Renew. Energy* 196, 151–160. doi:10.1016/j.renene.2022.06.125

Anser, M. K., Godil, D. I., Khan, M. A., Nassani, A. A., Askar, S. E., Zaman, K., et al. (2022). Nonlinearity in the relationship between COVID-19 cases and carbon damages: Controlling financial development, green energy, and R&D expenditures for shared prosperity. *Environ. Sci. Pollut. Res.* 29 (4), 5648–5660. doi:10.1007/s11356-021-15978-w

Awan, U. (2019b). Effects of buyer-supplier relationship on social performance improvement and innovation performance improvement. *Int. J. Appl. Manag. Sci.* 11 (1), 21–35. doi:10.1504/ijams.2019.096657

Awan, U., Gölgeci, I., Makhmadshoev, D., and Mishra, N. (2022). Industry 4.0 and circular economy in an era of global value chains: What have we learned and what is still to be explored? *J. Clean. Prod.* 371, 133621. doi:10.1016/j.jclepro.2022.133621

Awan, U. (2019a). Impact of social supply chain practices on social sustainability performance in manufacturing firms. *Int. J. Innovation Sustain. Dev.* 13 (2), 198–219. doi:10.1504/ijisd.2019.10019789

Awan, U., Kraslawski, A., and Huiskonen, J. (2018). The impact of relational governance on performance improvement in export manufacturing firms. *J. Industrial Eng. Manag.* 11 (3), 349–370. doi:10.3926/jiem.2558

Awan, U., and Sroufe, R. (2020). Interorganisational collaboration for innovation improvement in manufacturing firms's: The mediating role of social performance. *Int. J. Innov. Mgt.* 24 (05), 2050049. doi:10.1142/s1363919620500498

Awan, U., and Sroufe, R. (2022). Sustainability in the circular economy: Insights and dynamics of designing circular business models. *Appl. Sci.* 12 (3), 1521. doi:10.3390/app12031521

Bashir, A., Susetyo, D., Suhel, S., and Azwardi, A. (2021). Relationships between urbanization, economic growth, energy consumption, and CO 2 emissions: Empirical evidence from Indonesia. *J. Asian Finance, Econ. Bus.* 8 (3), 79–90.

Batool, R., Sharif, A., Islam, T., Zaman, K., Shoukry, A. M., Sharkawy, M. A., et al. (2019). Green is clean: The role of ICT in resource management. *Environ. Sci. Pollut. Res.* 26 (24), 25341–25358. doi:10.1007/s11356-019-05748-0

Chandrarin, G., Sohag, K., Cahyaningsih, D. S., and Yuniawan, D. (2022). Will economic sophistication contribute to Indonesia's emission target? A decomposed analysis. *Technol. Forecast. Soc. Change* 181, 121758. doi:10.1016/j.techfore.2022.121758

Gunawan, J., Permatasari, P., and Fauzi, H. (2022). The evolution of sustainability reporting practices in Indonesia. *J. Clean. Prod.* 358, 131798. doi:10.1016/j.jclepro.2022.131798

Hanif, S., Lateef, M., Hussain, K., Hyder, S., Usman, B., Zaman, K., et al. (2022). Controlling air pollution by lowering methane emissions, conserving natural resources, and slowing urbanization in a panel of selected Asian economies. *Plos one* 17 (8), e0271387. doi:10.1371/journal.pone.0271387

Heryadi, M. D., and Hartono, D. (2017). Energy efficiency, utilization of renewable energies, and carbon dioxide emission: Case study of G20 countries. *Int. Energy J.* 16 (4), 143–152.

Huber, P. J. (1973). Robust regression: Asymptotics, conjectures and Monte Carlo. *Ann. Stat.* 1 (5), 799–821. doi:10.1214/aos/1176342503

Khan, H. U. R., Nassani, A. A., Aldakhil, A. M., Abro, M. M. Q., Islam, T., and Zaman, K. (2019). Pro-poor growth and sustainable development framework: Evidence from two step GMM estimator. *J. Clean. Prod.* 206, 767–784. doi:10.1016/j.jclepro.2018.09.195

Kilinc-Ata, N. (2022). "The asymmetric impact of economic growth, energy consumption, population, and R&D on carbon emission in Turkey: Evidence from ARDL and non-linear ARDL," in *Handbook of research on sustainable development goals, climate change, and digitalization*. Editor R. Castanho (Hershey, PA: IGI Global), 200–215. doi:10.4018/978-1-7998-8482-8.ch013

Massagony, A., and Budiono, B. (2022). Is the environmental kuznets curve (EKC) hypothesis valid on CO2 emissions in Indonesia? *Int. J. Environ. Stud.*, 1–12. doi:10.1080/00207233.2022.2029097

Oktaviani, R., Amaliah, S., Ringler, C., Rosegrant, M. W., and Sulser, T. B. (2011). The impact of global climate change on the Indonesian economy. International Food Policy Research Institute. Available at https://www.ifpri.org/publication/impact-global-climate-change-indonesian-economy (accessed October 2, 2022).

Rousseeuw, P., and Yohai, V. (1984). "Robust regression by means of S-estimators," in *Robust and nonlinear time series analysis* (New York, NY: Springer), 256–272.

Salman, M., Long, X., Dauda, L., and Mensah, C. N. (2019). The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. *J. Clean. Prod.* 241, 118331. doi:10.1016/j.jclepro.2019.118331

Sugiawan, Y., Putri, M. S., Kaliwanto, B., and Sutarto, F. M. (2022). Decarbonization of Indonesia's economy: An analysis using machine learning methodAIP Conference Proceedings. *AIP Publ. LLC* 2501 (1), 020012.

Usaid (2022). Environment. Available at https://www.usaid.gov/indonesia/environment (accessed October 2, 2022).

Wen, Y., Song, P., Yang, D., and Gao, C. (2022). Does governance impact on the financial development-carbon dioxide emissions nexus in G20 countries. *Plos one* 17 (8), e0273546. doi:10.1371/journal.pone.0273546

World Bank (2022a). Global conditions pose risks for growth and inflation outlook in Indonesia, new World Bank report says. Available at https://www.worldbank.org/en/news/press-release/2022/06/22/global-conditions-pose-risks-for-growth-and-inflation-outlook-in-indonesia-new-world-bank-report-says (accessed October 2, 2022).

World Bank (2022b). *World development indicators*. Washington D.C: World Bank.

Yohai, V. J. (1987). High breakdown-point and high efficiency robust estimates for regression. *Ann. Stat.* 15 (2), 642–656. doi:10.1214/aos/1176350366

Zaman, K., Malik, M., Awan, U., Handayani, W., Jabor, M. K., Asif, M., et al. (2022). Environmental effects of bio-waste recycling on industrial circular economy and eco-sustainability. *Recycling* 7 (4), 60. doi:10.3390/recycling7040060

Zaman, K., Moemen, M. A. E., and Islam, T. (2017). Dynamic linkages between tourism transportation expenditures, carbon dioxide emission, energy consumption and growth factors: Evidence from the transition economies. *Curr. Issues Tour.* 20 (16), 1720–1735. doi:10.1080/13683500.2015.1135107