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The role of eco-innovation, eco-investing, and green bonds in achieving sustainable economic development: evidence from Vietnam

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ABSTRACT

The perpetual upsurge of global economic development and human actions has multiplied the intensity of carbon emissions that signifies the effectiveness eco-innovation, eco-investment and green bonds in order to curb carbon emissions. Thereby, the study attempts to examine the impact of eco-innovation, eco-investment, and green bonds on the achievement of sustainable economic development (S.E.D.) in Vietnamese economy. Secondary data was used and extracted from Organization for Economic Co-operation and Development (O.E.C.D.), central bank, and World Development Indicators (W.D.I.) from 1991 to 2020. Techniques such as dynamic Auto-regressive Distributed Lags (D.A.R.D.L.) model and Bayesian Auto-regressive Distributed Lags (B.A.R.D.L.) were employed to evaluate the relationship. Findings echo that that eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate share positive connection with the achievement of S.E.D. in Vietnam. The study guides the policy-making authorities that they should establish the policies related to S.E.D. by using eco-innovation and eco-investment.

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1. Introduction

The economy of a country regains sustainability when its fundamental objectives revolve around human welfare and focus on securing environmental and social well-being. It is to bring such a development in the economy as human needs are met by utilising available resources without any impact or with little impact on the environment

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and its belongings. The motive behind this must be that the fulfillment of current needs must not distort the needs of future generation (Abdul Hamid et al., 2020; Cvijanović et al., 2020). Economic practices such as employing machines, plants, electric appliances, logistics, and infrastructure, poor quality resources, operation activities, and production goods have an impact on the environment and can be destructive. Within the rapidly growing economies, such activities have negative impacts on the environment, including unresolvable toxic wastes, greenhouse gases (G.H.G.), smog, acid rain, disturbance in weather, water pollution, and land pollution. The environmental consequences of human activities are damaging to natural resources (living as well as non-living) and the health of the inhabitants who live in that area (Ainou et al., 2022; Ali et al., 2022; Ndubisi et al., 2021). Natural resources, including all living and non-living things, provide resources to businesses, work carrying on economic activities and meet people's needs. If these naturally occurring resources continue to be used and diminish, and the health of the people is not cared for, the social well-being and economic development come in danger, making it difficult for the country to stand on its feet and make development in the future. That is why it is compulsory for the country to incorporate environmental protection into economic development, which is sustainable economic development (S.E.D.; Bai et al., 2022; Hartani et al., 2021; Ma et al., 2022).

A major hurdle in the way to achieving S.E.D. is the CO_2 emission that is caused by human activities based on energy and creation wastes. Eco-innovation, eco-investing, and green bonds are the three green financing components, and these are all crucial in leading the economy towards S.E.D. because these tools assist in initiatives to reduce CO_2 emissions (Chien, 2022a; Zhang & Wang, 2021). Eco-innovation is the newness, improvement, value addition, or changes in the already applied resources, processes, and products features or services quality, and this novelty must restrict the negative environmental consequences of the business practices, products, and services (Chan et al., 2022; Chien, Chau, et al., 2022; Chien, Zhang, et al., 2022). Ecological innovation may be in different forms like sustainable energy transition, adoption of energy-efficient material and technologies, energy and material recovery from wastes, wastes disposal, eco-production, etc. The eco-innovation, by restricting non R.E.C. and reducing wastes, reduces carbon emissions. In this condition, the saved, healthy, and comfortable work environment, the abundant natural resources, and healthy workers bring S.E.D. (Chien, 2022b; Li et al., 2021).

Eco-investment is the funding of money into projects with environmental protection and social responsibility. There are three ways eco-investing reduces CO_2 emissions (Chien et al., 2021; Pimonenko et al., 2020). First, it encourages the energy transition and promotes the use of R.E. Moreover, the use of R.E. in place of non-R.E. mitigate harmful emissions. Second, eco-investing encourages energy efficiency, that is, the reduced use of energy. Third, eco-investment encourages absorbing existing CO_2 emissions from the air. The reduction of CO_2 emissions as a result of eco-investing secures the environment from destruction and protects the social well-being of the people as well. Quality resources and active, motivated labour from the healthy, prosperous public are the way to achieve S.E.D. (Haroon et al., 2021; Kamarudin et al., 2021; Lagoarde-Segot, 2020). A green bond is a form of green finance. It is a significant instrument to establish a sustainable economy. In the economies where the green bond issuance is increasing, the frequency of ecological friendly projects is increasing as well. As a result, there is a check on the activities causing CO_2 emissions. The reduction of CO_2 emissions provides a foundation for the country to achieve S.E.D. (Khattak et al., 2021; Lan et al., 2022; Syed et al., 2022).

This article examines the eco-innovation, eco-investment, and green bonds, along with industrialisation, inflation, and employment rate role in reducing CO_2 emissions and achieving S.E.D. for Vietnam. Vietnam is an emerging economy with an upper-middle-income economy. It is the 37th-largest country in the world in terms of nominal G.D.P., which is $404.105 billion in 2022, and the 23rd-largest country in the world in terms of purchasing power parity (PPP) which is $1.24 trillion in 2022 (Liu, Yin, et al., 2022; Nong et al., 2020). It is based on three sectors: agriculture, industry, and service. Agriculture, which has no significant adverse impact on the environment, is limited as per G.D.P. share. The industrial and service sectors, which apply technologies, machines, chemicals, infrastructure, and transportation, are major economic sectors (Lin et al., 2022; Nguyen et al., 2021). Energy consumption has been increasing in Vietnam. The rate of increase in energy consumption is 9.98%/year. It represented the increase from 76 billion kWh in 1992 to 1,144 billion kWh in 2020. In the overall energy consumption in Vietnam, the non-renewable energy usage has increased 12 times, from 75 billion kWh to 972 billion kWh. At the same time, renewable energy usage has increased from 0 kWh to 174 billion kWh (Liu, Lan, et al., 2022; Tien et al., 2020).

The increasing use of energy in social and economic activities is the source of CO_2 emissions in the country. The per capita CO_2 emissions are 2.72 metric tons in Vietnam in 2021 (Shultz & Peterson, 2019; Yousaf et al., 2021). Though Vietnam is an emerging economy and making fast progress, it is feared to collapse in the future because it faces environmental issues. These environmental issues are damaging to natural resources, whether they are living or non-living, and the work context is also disturbed (Heller et al., 2020; Piligrimienė et al., 2021). So, there is a need for attention towards reducing environmental pollution and achieving sustainable economic development. The present study is aimed to meet this need. Its objective is to examine the impacts of eco-innovation, eco-investment, and green bonds, along with industrialisation, inflation, and employment rate, on reducing CO_2 emissions and achieving S.E.D. for Vietnam. It has several literary contributions.

First, some academics have recorded the influences of eco-innovation, eco-investment, and green bonds in achieving S.E.D. in their writings. But these variables have been analysed separately as predictors of sustainable economic development. The present study, which explores the role of eco-innovation, eco-investment, and green bonds in achieving sustainable economic development, makes a distinction in literature. Second, in past literature, environmental degradation or G.H.G. emission has been taken for predicting sustainable economic development. This study makes a contribution by using CO_2 emissions as the predictor of sustainable economic development. Third, the issue that CO_2 emissions have been increasing because of the increasing use of non-renewable energy and related factors, and there has been a threat to economic development has been in Vietnam for a long. But there is little research on the influences of eco-innovation, eco-investment, and green bonds on

CO_2 emissions and S.E.D. in different. The present research removes this gap as it analyses the nexus among factors in Vietnam.

The rest of the article is structured as follows: The second part deals with the review of the literature on the nexus among the role of eco-innovation, eco-investment, green bonds, industrialisation, inflation, employment rate, CO_2 emissions and sustainable economic development. The third portion states the methods applied for collecting the data about the factors understudy and the analytical techniques. In the next portion, the results of the research are given, and these results are supported by the findings of similar past studies. Then, the study implications, conclusion, and limitations are given.

2. Literature review

S.E.D. is to promote an economy where the economic actors not only focus on earning financial profits or meeting just economic goals but are also attentive to securing the natural environment and people's social welfare. It is the country's development where resources are utilised in a manner that not only the current economic goals can be accomplished, but there is space to expand the economy further and achieve future economic goals. The expansion in the economic activities based on energy, especially non-renewable energy like manufacturing, infrastructure, transportation, energy generation, etc., can be threatening to future generations' well-being by deteriorating environment and concerned resources (Gadeikienė & Švarcaitė, 2021; Jermsittiparsert, 2021; Phan et al., 2020). Eco-innovation, eco-investment, and green bonds are the three initiatives whose basic objective is to overcome environmental concerns, which are significant to attain sustainable economic development. These initiatives reduce CO_2 emissions, protect resources and improve people's well-being. So, there is sustainable economic development. The present study examines the role of eco-innovation, eco-investment, and green bonds along with industrialisation, inflation, and employment rate in reducing CO_2 emissions and achieving S.E.D. (Moslehpour, Chau, Du, et al., 2022; Moslehpour, Chau, Tu, et al., 2022; Moslehpour, Shalehah, et al., 2022). The authors and scholars have analysed the impact of eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate in reducing CO_2 emissions and achieving sustainable economic development. In the following paragraphs, the impacts of eco-innovation, eco-investment, and green bonds along with industrialisation, inflation, and employment rate on CO_2 emissions and S.E.D. in light of previous research (Kurniawan et al., 2022; Thitinan & Chankoson Khunanan, 2022).

The adoption of eco-innovation brings an improvement-based change in either a few or all the business practices like infrastructure, operational activities, manufacturing processes, and transportation. This change reduces the environmental impacts of business operations and its products because it assists in controlling the usage of unclean energy and the resultant CO_2 emissions. The increasing trend of eco-innovation within the economy assures environmental protection, reduces climate change, protects the health of living beings, and secures nature-based resources, which are all useful in the economy. Hence, eco-innovation with the reduction of CO_2 emissions helps achieve S.E.D. (Antinienė et al., 2021; Lee et al., 2018). The study conducted by Chien et al. (2021) and Sadiq, Amayri, et al. (2022) investigates the role of eco-innovation, environmental taxes, and green energy in reducing CO_2 emissions and achieving sustainable economic development. The evidential data for eco-innovation, environmental taxes, green energy, CO_2 emissions and S.E.D. was collected from the U.S.A. from 1970 to 2015. The research employed the Q.A.R.D.L. method for analysing the data and finding results. The study reveals that eco-innovation is a key solution to the problem of CO_2 emissions, and so it is a way to gain sustainability in economic development as it guarantees a sustainable work environment and quality resources. Through empirical research, Triguero et al. (2022) identify the role of eco-innovation in reducing CO_2 emissions and sustainable development. The authors find that with eco-friendly innovation, environmental pollution like CO_2 emissions can be controlled to a specific level, and the resources that are vital to S.E.D. can be protected. Ji et al. (2021) and Sadiq, Ngo, et al. (2022), checks the significance of eco-innovation and fiscal decentralisation in environmental sustainability and sustainable economic development. The research survey was done on fiscal decentralisation in Germany, Spain, Australia, Austria, Belgium, Canada, and Switzerland for the time period 1990–2018. The panel data econometric tools are used for the dependence of cross-sections and heterogeneous coefficients. The research finds that eco-innovation is useful to resolve environmental issues like CO_2 emissions that are caused by backward technologies and fossil fuels consumption. Thus, sustainable development, which requires a pleasant work atmosphere, abundant natural resources, and healthy labour, is possible to achieve. Mahmood et al. (2022) and Sadiq, Ou, et al. (2022), examine the influences of the role of eco-innovation and environmental regulations in energy structure transition for sustainable economic development. The data was collected for the variables of interest from Organization for Economic Co-operation and Development (O.E.C.D.) countries between 1994 and 2020. The advanced panel data evaluation techniques were applied to resolve the issues of endogeneity, serial correlation, heteroscedasticity, and cross-sectional dependency. The study posits that eco-innovation adoption encourages energy transition from non-renewable to renewable resources. Consequently, the reduction of CO_2 emissions helps achieve sustainable economic development.

The study presented by Sriyakul et al. (2022) and Tran et al. (2020) investigates the relation of eco-investing to S.E.D. with the reduction of CO_2 emissions. The data set for eco-investment, CO_2 emissions, and eco-investing benefits for S.E.D. from 208 businesses operating in diverse industries in Vietnam for the year 2018. For the empirical research, the Exploratory Factor Analysis (E.F.A.) methodology was employed. The study reveals that eco-investing is positively associated with reducing CO_2 emissions and sustainable economic development. It states that eco-investing is useful to implement the strategies that are meant to continue the business practices without much affecting the environment. So, there is a reduction in CO_2 emissions and sustainable economic development. Huang et al. (2021) discussed about eco-investment, renewable energy and technological innovation and their role in reducing carbon emissions and achieving sustainable economic development. The findings of the C.S.-A.R.D.L. technique showed that eco-investing has a positive contribution to reducing CO_2 emissions and achieving sustainable economic development. Eco-investing encourages green activities like better sanitation systems, eco-friendly transportation, clean energy consumption, waste management, plantation, etc. Consequently, the lower CO_2 emissions clear the way for the country to achieve sustainable economic development. Lyeonov et al. (2019), examines the impacts of eco-investment on renewable energy, CO_2 emissions and S.E.D. in the E.U. countries during the period 2008–2016. For this research, the data was taken from the databases like the World Data Bank, Eurostat, and the European Environmental Agency. For enumerating the relation among these factors, methods like Pedroni panel cointegration tests, panel unit root tests, and F.M.O.L.S. and D.O.L.S. techniques were applied. The study conveys that in the states where eco-investment is being encouraged at a high level, the technologies or machines which require renewable energy to work are employed (Van Hoa et al., 2022). These technologies or machines cause CO_2 emissions in a minimum amount, and there are chances to achieve sustainable economic development. Shahzad et al. (2021), enumerate the role of eco-investing in reducing CO_2 emissions and achieving sustainable economic development. The study posits that with the increase in eco-investing within the country, CO_2 emissions amount within the air can be controlled. And the saved resources assure sustainable economic development. The study Pang et al. (2022) and Tan et al. (2021) evaluates the connection of natural resource rent and eco-investing with S.E.D. The economy of China during 1990–2018 is the source of evidence for the factors of interest in this research. The novel empirical evaluation technique, Q.A.R.D.L., was applied. The findings show that the increase in the eco-investing tendency among the economic actors put their attention on the reduction of CO_2 emission and help to attain sustainability in economic development. Hence, eco-investing is positively linked to sustainable economic development.

The literary article of Tolliver et al. (2019) analyses the role of the green bond in implementing the Paris agreement and sustainable economic development. The research is based on the data from the 53 organisations which had green bond proceeds allocations to assets and projects throughout 96 countries during 2008–2017. The study proclaims that the assets and projects financed using green bonds reduce more than 108 million tons of carbon dioxide and increase renewable energy capacity by more than 1500 gigawatts. This leads the economy towards sustainable development. Hence, green bonds and S.E.D. are connected positively. The study conducted by Ahmed et al. (2022) and Zhao et al. (2021) examines the impacts of green bonds, community-based green funds, green banks, and green central banking on green energy, CO_2 emissions, and sustainable economic development. The authors employed the S.T.I.R.P.A.T. model approach and gathered data from six A.S.E.A.N. member states over the years during 2002–2018. The study showed that green bonds, a green finance instrument, provide funds for employing green energy systems and improving energy efficiency. The use of green energy and the reduced use of total energy for performing the same activities reduces CO_2 emissions. It is significant to achieve S.E.D. by protecting economic resources. Tolliver et al. (2020), wrote about the influences of green bonds on the Paris agreement and sustainable economic development. Employing the structural equation model, the empirical data for the green bonds, CO_2 emissions level, and sustainable development were taken from 49 O.E.C.D. countries covering the years between 2007 and 2017. The study implies that the Paris agreement, which is specifically for controlling climate change by reducing

CO_2 emissions, can be executed with green bond investments, and it opens ways to achieve sustainable development in those countries. Likewise, Hussain et al. (2022) and Zhao et al. (2022) checks how CO_2 emissions can be controlled and S.E.D. can be achieved. CO_2 emissions are the major issue of emissions generating companies for consuming energy resources. It requires controlling CO_2 emissions, but most companies are unable to reduce them just because they lack green technologies. Green bonds are a source of investment in implementing green technologies. The resultant decrease in CO_2 emissions leads the countries to have S.E.D. Sartzetakis (2021), throws light on the green bonds, low carbon transition, and S.E.D. The study posits that for S.E.D., it is necessary for the countries to secure the living and non-natural resources which are utilised in the economic development and health of the people whose services are required. The low carbon transition is essential in this regard, and the green bonds are an effective source of investment in low carbon transition. Hence, green bonds have a positive relation to reducing CO_2 emissions and achieving sustainable economic development.

Opoku and Boachie (2020), investigates industrialisation and its role in S.E.D. The empirical data was collected from 37 African countries between 1980 and 2014. The study proclaims that industrialisation has a positive association with S.E.D. When the industry of a country grows rapidly, there is prosperity, and they can afford modern energy-efficient technologies. The reduction of CO_2 emissions allows the country to make S.E.D. Rehman et al. (2021), debate on industrialisation, energy import, and sustainable development. Information about industrialisation, energy import, carbon emissions and economic growth in Pakistani economy and the survey was conducted over the period from 1971 to 2019. The results showed that industrialisation with renewable energy import and reducing CO_2 enhances sustainability in economic development.

The study conducted by Athari et al. (2021) checks the inflation impacts on carbon emissions and S.E.D. with respect to the tourism industry. The panel data was acquired from 76 destinations between 1995 and 2017. The pooled ordinary least squares (O.L.S.) and GMM methods were applied to the empirical analysis of the relations among factors. The results revealed a positive relation between inflation with carbon emissions and S.E.D. If there is inflation, the income level of the industries goes to height suddenly. They can afford improvement in the energy pattern, and so overcome the environmental impacts. Hence, they can make their economic development sustainable. Din et al. (2022), analyses inflation, savings, financial development and sustainable economic development. The South Asian developing economies provided the context for the analysis of the nexus among factors. The study conveys that during inflation, there is a rise in savings and financial development, and this encourages clean energy consumption, discourages CO_2 emissions and assists in achieving sustainable economic development.

Maku and Alimi (2018), throws light on the role of employment rate and fiscal policy tools in reducing CO_2 emissions and sustainable economic development. The authors analysed these factors in Nigeria for the period 1980–2015. The study posits that the increase in the employment rate solves many problems which are a hurdle in achieving sustainable economic development. It assists in reducing CO_2 emissions by encouraging green energy consumption and saves natural resources, which provide surety to sustainability in economic development. Similarly, Aldieri and Vinci (2018), also debate the employment rate contribution to S.E.D. The study reveals that the increase in the employment rate improves the financial condition of the population. They can adopt advanced technologies encouraging sustainable energy with minimum CO_2 emissions. Hence, there may be sustainable economic development.

3. Methodology

The study evaluates eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate and their role in S.E.D. in Vietnamese context. Secondary data has been extracted from O.E.C.D., central bank, and W.D.I. from 1991 to 2020. The study has established the equation as under:

$$SED_t = \alpha_0 + \beta_1 EIN_t + \beta_2 EINV_t + \beta_3 GB_t + \beta_4 IND_t + \beta_5 INF_t + \beta_6 EMR_t + e_t \quad (1)$$

where;
CO_2 = Carbon Dioxide Emissions
t = Time Period
EIN = Eco-innovation
EINV = Eco-investment
GB = Green Bonds
IND = Industrialisation
INF = Inflation
EMP = Employment Rate

These measurements, sources, and variables are given in Table 1.

The article has checked the variables' properties through descriptive statistics. Moreover, the directional linkage between the constructs has also been checked through correlation matrix. Furthermore, the unit root among the constructs has also

Table 1. Measurements of variables.

S#	Variables	Measurement	Sources
01	Sustainable Economic Development	CO_2 emissions (metric ton per capita)	WDI
02	Eco-innovation	Eco-innovation index	OECD
03	Eco-investment	Investment in environmentally friendly companies to total investment	OECD
04	Green Bonds	The ratio of green bonds to total bonds	Central Bank
05	Control Variables	Industry value added (% of GDP)	WDI
		Consumer price (Annual percentage)	WDI
		Employment in industry (percentage of total employment)	WDI

Source: Authors' estimation.

been monitored through Augmented Dickey-Fuller (A.D.F.) along with Phillips–Perron (PP) tests. The equation for the tests is given as under:

$$d(Y_t) = \alpha_0 + \beta t + \Upsilon Y_{t-1} + d(Y_t(-1)) + \varepsilon_t \quad (2)$$

In addition, the study has also investigated the co-integration between the variables with the help of Westerlund and Edgerton (2008) approach. The null hypothesis of the test shows no co-integration exists. The equations for the approach are given as under:

$$\mathrm{LM}_{\varphi}(\mathrm{i}) = \mathrm{T}\hat{\varphi}_{\mathrm{i}} \ (\hat{\mathrm{r}}_{\mathrm{i}}/\hat{\sigma}_{\mathrm{i}}) \quad (3)$$

$$\mathrm{LM}_{\tau}(\mathrm{i}) = \hat{\varphi}_{\mathrm{i}}/\mathrm{SE}(\hat{\varphi}_{\mathrm{i}}) \quad (4)$$

In the above equations, $\hat{\varphi}_i$ refers to the estimate beside $\hat{\sigma}_i$ standard error, $\hat{r}_i^2$ refers to the long-run measured variance of $_{\mathrm{it}}$, $\varphi i\ (L) = 1 - \sum \varphi_{ij} L^j$ refers to the scalar polynomial with L lag length, and the ρ_{i} refers to the factor loading parameters vector.

The current study has checked the linkage among the variables with the help of the A.R.D.L. model because it is suitable for the study when its variable has no unit root at I(0) and I(1). In addition, it also provides the association among variables in the short- and long-run (Zaidi & Saidi, 2018). Finally, it also controls the severe effects of heteroscedasticity along with autocorrelation (Nazir et al., 2018). The A.R.D.L. estimation equation is mentioned below:

$$\begin{aligned}\Delta CO2_t = \alpha_0 &+ \sum \delta_1 \Delta CO2_{t-1} + \sum \delta_2 \Delta ECI_{t-1} + \sum \delta_3 \Delta EIN_{t-1} \\ &+ \sum \delta_4 \Delta GB_{t-1} + \sum \delta_5 \Delta IND_{t-1} + \sum \delta_6 \Delta INF_{t-1} + \sum \delta_7 \Delta EMR_{t-1} \\ &+ \varphi_1 CO2_{t-1} + \varphi_2 ECI_{t-1} + \varphi_3 EIN_{t-1} + \varphi_4 GB_{t-1} \\ &+ \varphi_5 IND_{t-1} + \varphi_6 INF_{t-1} + \varphi_7 EMR_{t-1} + \varepsilon_t \end{aligned} \quad (5)$$

In addition, the article has checked the linkage between the variable with the help of a newly developed approach called dynamic auto-regressive distributed lags (D.A.R.D.L.). This approach is established by Jordan and Philips (2018). It has the ability to cover the shortcoming that exists in the A.R.D.L. approach while evaluating long and short-run linkage among variables. Dynamic A.R.D.L. is also a suitable model for the study if the co-integration exists. The equation is given below:

$$\begin{aligned}\Delta CO2_t = \alpha_0 &+ \sum \delta_1 \Delta CO2_{t-1} + \sum \delta_2 \Delta ECI_t + \sum \delta_3 \Delta ECI_{t-1} + \sum \delta_4 \Delta EIN_t \\ &+ \sum \delta_5 \Delta EIN_{t-1} + \sum \delta_6 \Delta GB_t + \sum \delta_7 \Delta GB_{t-1} + \sum \delta_8 \Delta IND_t \\ &+ \sum \delta_9 \Delta IND_{t-1} + \sum \delta_{10} \Delta INF_t + \sum \delta_{11} \Delta INF_{t-1} + \sum \delta_{12} \Delta EMR_t \\ &+ \sum \delta_{13} \Delta EMR_{t-1} + \varepsilon_t \end{aligned} \quad (6)$$

Finally, for robustness, the study has also examined the Bayesian inference analysis that assumed the estimation parameters are random while the observed data is fixed.

Moreover, Bayesian inference analysis provides the probabilities that show the likely or unlikely effects of predictors on predictive constructs (Salakpi et al., 2022). Thus, the estimated model for Bayesian inference analysis is given as under:

$$Y_t \sim N + \beta^T X_t , \delta^2 I \quad (7)$$

In Equation (7), Y_t is the CO_2 emissions while the X_t is the matrix of predictors. In addition, β^T shows the transposed weight matrix while δ^2 shows the variance, and I show the identity matrix. The Bayesian estimator produced the posterior distribution using prior outputs, observed data, and knowledge (Ngoc & Awan, 2022). The posterior distribution of the Bayesian estimator is estimated as under:

$$P(\beta/Y_t, X_t) = \frac{P(Y_t/\beta, X_t) * P(\beta/X_t)}{P(Y_t/X_t)} \quad (8)$$

In Equation (8), $P(Y_t/\beta, X_t)$ refers to the likelihood of the data, $P(\beta/X_t)$ refers to the prior probability data parameters, and $P(Y_t/X_t)$ refers to the normalisation constant. Moreover, the article also employed an adaptive random-walk Metropolis-Hastings algorithm to avoid spurious convergence and prove the effects of eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate on the CO_2 emissions.

4. Findings results

The article has checked data normality through descriptive statistics. The study results exposed that the CO_2 mean value was 1.321 metric tons per capita, while E.C.I. average value was 0.592%, and the E.I.N. mean value was 0.355%. Moreover, it is also exposed from the findings that average value of G.B. is 0.273% followed by I.N.D. 04.118%, I.N.F. 5.991% and E.M.R. 18.059%. These outcomes are given in Table 2.

In addition, the study also checked the year-wise details of all the variables using descriptive statistics by year (see Table 3). The outcomes exposed that the highest CO_2 emissions were in 2019, while the largest E.C.I. was in 2019, and the highest E.I.N. and G.B. were in 2020. Finally, the outcomes revealed that the highest I.N.D. was in 2020, while the largest I.N.F. was in 2008, and the highest was in 2019.

Moreover, the directional linkage between the constructs has also been checked through correlation matrix. Results indicated that eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate are negatively correlated with CO_2 emissions but positively correlated with the achievement of S.E.D. (see Table 4).

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	30	1.321	0.890	0.285	3.488
ECI	30	0.592	0.063	0.488	0.708
EIN	30	0.355	0.052	0.266	0.440
GB	30	0.273	0.040	0.211	0.338
IND	30	4.118	0.560	3.109	5.037
INF	30	5.991	4.879	−1.710	23.115
EMR	30	18.059	5.609	10.12	27.44

Source: Authors' estimation.

Table 3. Descriptive statistics (years).

	CO_2	ECI	EIN	GB	IND	INF	EMR
1991	0.285	0.488	0.266	0.211	3.299	5.738	10.120
1992	0.294	0.496	0.279	0.212	3.109	5.756	10.580
1993	0.335	0.503	0.279	0.213	3.357	5.773	11.090
1994	0.362	0.510	0.289	0.217	3.390	5.791	11.470
1995	0.419	0.517	0.291	0.229	3.454	5.808	11.820
1996	0.461	0.524	0.298	0.231	3.517	5.675	12.250
1997	0.529	0.531	0.304	0.235	3.580	3.210	12.680
1998	0.582	0.538	0.310	0.239	3.644	7.266	11.580
1999	0.587	0.545	0.316	0.244	3.707	4.117	11.990
2000	0.641	0.553	0.322	0.248	3.770	−1.710	12.440
2001	0.702	0.560	0.328	0.253	3.834	−0.432	13.900
2002	0.816	0.567	0.334	0.257	3.897	3.831	14.700
2003	0.861	0.574	0.340	0.262	3.960	3.235	16.410
2004	1.024	0.581	0.346	0.266	4.024	7.755	17.350
2005	1.102	0.588	0.352	0.271	4.087	8.285	18.740
2006	1.121	0.595	0.358	0.275	4.150	7.418	20.190
2007	1.231	0.603	0.363	0.280	4.214	8.344	20.390
2008	1.363	0.610	0.369	0.284	4.277	23.115	21.000
2009	1.519	0.617	0.375	0.289	4.340	6.717	21.850
2010	1.721	0.657	0.381	0.293	4.404	9.207	21.680
2011	1.755	0.618	0.387	0.298	4.467	18.678	21.280
2012	1.732	0.627	0.393	0.302	4.530	9.095	21.190
2013	1.810	0.637	0.399	0.307	4.594	6.593	21.180
2014	1.972	0.646	0.405	0.311	4.657	4.085	21.450
2015	2.381	0.655	0.411	0.316	4.720	0.631	22.740
2016	2.389	0.665	0.417	0.320	4.784	2.668	24.760
2017	2.436	0.666	0.423	0.325	4.847	3.520	25.780
2018	2.989	0.687	0.429	0.329	4.910	3.540	26.640
2019	3.488	0.708	0.434	0.334	4.974	2.796	27.440
2020	2.729	0.690	0.440	0.338	5.037	3.221	27.089

Source: Authors' estimation.

Table 4. Correlation.

Variables	CO_2	ECI	EIN	GB	IND	INF	EMR
CO_2	1.000						
ECI	−0.967	1.000					
EIN	−0.960	0.991	1.000				
GB	−0.960	0.991	0.999	1.000			
IND	−0.958	0.989	0.997	0.998	1.000		
INF	−0.039	0.020	0.031	0.031	0.031	1.000	
EMR	−0.955	0.978	0.977	0.977	0.976	0.109	1.000

Source: Authors' estimation.

Furthermore, the unit root has also been investigated through A.D.F. and .P.P tests. Findings proclaimed that the CO_2, E.C.I., I.N.F., and E.M.R. are stationary at level; in contrast, E.I.N., G.B., and I.N.F. are stationary at 1st difference (see Table 5).

In addition, co-integration between the variables has been scrutinised through Westerlund and Edgerton (2008) approach. Findings showcase that p-values are $<$ 0.05 while the t-values are $>$ 1.96. It implies that co-integration exists (see Table 6).

The results of the dynamic A.R.D.L. model indicated that eco-innovation, eco-investment, green bonds, industrialisation, inflation, and employment rate have a negative linkage with CO_2 emissions but a positive association with the achievement of S.E.D. in Vietnam (see Table 7). The outcomes also expose that the 58.876% changes in CO_2 emissions happens because of the chosen predictors.

Table 5. Unit root test.

ADF PP				
Series	Level	First difference	Level	First difference
CO_2	−2.901***	–	−2.102***	–
ECI	−3.082***	–	−3.010***	–
EIN	–	−5.093***	–	−5.019***
GB	–	−5.355***	–	−5.288***
IND	–	−5.029***	–	−5.883***
INF	−3.104***	–	−3.204***	–
EMR	−3.267***	–	−3.764***	–

Source: Authors' estimation.

Table 6. Co-integration test.

	No shift		Mean shift		Regime shift	
Model	t-stat	*p*-value	t-stat	*p*-value	t-stat	*p*-value
LM_{τ}	−4.212	.00	−5.774	0.000	−6.432	.00
LM_{φ}	−4.892	.00	−5.102	0.000	−6.836	.00

Source: Authors' estimation.

Table 7. Dynamic A.R.D.L. model.

Variable	Coefficient	t-Statistic	Prob.
ECT	−2.730***	−4.339	0.000
ECI_{t-1}	−1.883***	−5.639	0.000
ECI	−0.654**	−3.326	0.017
EIN_{t-1}	−2.764*	−1.916	0.055
EIN	−1.920***	−4.745	0.000
GB_{t-1}	−2.981***	−5.714	0.000
GB	−1.928***	−4.902	0.000
IND_{t-1}	−3.673**	−3.212	0.019
IND	−2.091**	−2.949	0.043
INF_{t-1}	−1.282**	−2.102	0.046
INF	−2.922**	−3.019	0.021
EMR_{t-1}	−4.829***	−4.901	0.000
EMR	−3.256**	−2.102	0.032
Cons	−3.782**	−2.432	0.030

R square = 58.876 Stimulation = 5000.
Source: Authors' estimation.

The results of Bayesian analysis indicated that ecological innovation, eco-investment, green bonds, industrialisation, inflation and employment rate is negatively connected with CO_2 emissions but a positive association with the achievement of S.E.D. in Vietnam. Moreover, the acceptance rate is higher than optimal acceptance ($0.380 > 0.234$), the standard deviation figures are not large, and the Monte Carlo chain standard errors (M.C.S.E.) are approximately 1. Hence, the Bayesian inference is valid (see Table 8).

5. Discussion

The results showed that eco-innovation is connected with S.E.D. positively. The eco-innovation reduces the pollutants like CO_2 emissions that are a threat to social and economic prosperity. Thereby, it helps the country achieve sustainable economic development, which needs abundant quality resources, an active labour force, and a comfortable work environment. Findings are consistent with Dogaru (2020). The study posits that

Table 8. Bayesian analysis results.

Variables	Mean	Std. Dev.	MCSE	Prob. of mean > 0	Interval
ECI	−4.909	0.654	0.031	0.934	−4.092, −2.222
EIN	−4.893	0.383	0.051	1	−2.652, −0.991
GB	−3.902	0.873	0.027	1	−2.774, −0.732
IND	6.093	0.887	0.042	1	−3.674, −1.787
INF	−3.289	0.547	0.071	0.862	−2.102, −0.273
EMR	−5.982	0.620	0.034	1	−2.566, −0.102
Intercept	−50.663	7.627	0.410	1	−2.768, −1.842
e.ME Sigma2	0.643	0.773	0.017		1.549, 3.744
					Acceptance rate = 0.380

Source: Authors' estimation.

ecologically friendly innovation improves not only economic conditions but reduces the environmental impacts of business activities. The CO_2 emissions decrease in the organisations where eco-innovation is applied. The decrease in environmental pollution, like CO_2 emissions, enables the country to carry on its economic activities consistently. So, eco-innovation leads to achieving S.E.D. These results are also in line with Chistov et al. (2021) and Wirsbinna & Grega (2021), which highlights that the companies which apply eco-innovation, like energy transition, encourage energy efficiency, and properly handle harmful wastes, have to face a minimum amount of carbon emissions. Eco-innovation protects the work environment, secures the natural resources which are associated with the economy, and assures a healthy and efficient workforce.

The results showed that eco-investing is positively connected with S.E.D. In the areas where investment is encouraged to be made in the ecologically friendly activities along with the economic processes, there is facility and consistency in the economic activities without causing CO_2 emissions. Nature's resilience, abundant quality resources, and healthy living resources develop S.E.D. These results are supported by Yoshino et al. (2021). This previous study examines the role of eco-investing in sustainable economic development. It conveys that for implementing environmentally friendly initiatives to reduce the environmental consequences of human activities, a large amount of capital is required. If in an economy, banks or financial institutions cooperate for eco-investment, ecologically friendly initiatives can be taken. As a result, there is a reduction in CO_2 emissions, which helps in achieving S.E.D. Result are in line with Shen et al. (2021). This study also confirms that the countries where there is a trend to make eco-investment in social and economic programs, the amount of CO_2 emissions into the air can be controlled, and the natural resources are saved from excessive carbon in the atmosphere. In this way, the life of the economy can be enhanced. So, eco-innovation positively influences sustainable economic development.

The results showed that green bonds have a positive association with S.E.D. In Vietnam, there is a threat to S.E.D. The major threat is in the form of environmental deterioration like CO_2 emissions that is because of the lack of green activities. The issuance of green bonds provides a capital resource for many environmentally friendly programs, and by reducing CO_2 emissions, sustainability can be created in economic development. These results are in line with Maltais and Nykvist (2020), which is about the role of green bonds in sustainable economic development. This past study conveys that the issuance of the green bond enhances the financial capacity of the businesses and thereby allows them to apply energy-efficient resources and innovative technologies that may give the same productivity with the minimum energy. The lower use of energy decreases the total CO_2 emissions. Therefore, economic development can be sustainable. Findings are linked with Azhgaliyeva et al. (2020) and Shibli et al. (2021), which shows that during the performance of business activities, the use of material, energy resources, and chemicals leaves harmful wastes which cause CO_2 emissions. The investment through green bonds improves business processes and overcomes waste emissions. In this way, the economy can have sustainable development.

Findings exposed that industrialisation is positively associated with SEd. With the rise in the industry of a country, there is technological advancement, energy transition, energy efficiency, and development of nature's resilience as industrialisation enhances financial development and manufacturing level. The CO_2 emissions can be controlled, and economic development can be sustainable. These results agree with Barbieri et al. (2020) and Ojogiwa (2021), which reveals that in an economy whose industrial sector is growing rapidly, the companies can have the financial capacity to acquire advanced technologies, which can be useful to maintain the quality of the work environment. These technologies reduce the use of non-renewable energy, and the reduced CO_2 emission develops sustainability in economic growth. These results are also in line with Shi et al. (2021). According to the previous study, the areas where the industrial sector is making growth have financial prosperity. In these areas, it is possible to implement renewable energy systems like solar, wind, geothermal, etc. It decreases CO_2 emissions and thereby leads the country to have sustainable economic development.

The results showed that inflation has a positive association with S.E.D. The occurrence of the inflationary period improves the income level; there is a rise in economic and socially prosperous. In a prosperous country, CO_2 emissions can be reduced, and S.E.D. can be attained. These results are in line with Koirala et al. (2018) and Sadiq et al. (2022), which also states that the countries with rising inflation are able to overcome pollution emissions, and with a sustainable environment, they can have S.E.D. These results are also supported by Khan et al. (2022), which reveals that in the inflationary period, the strength of the economy to overcome environmental concerns is high. So, when there is a reduction in CO_2 emissions, there is sustainable economic development. The results showed that the employment rate has a positive association with sustainable economic development. The increase in the employment rate shows financial prosperity and a rising income level. In this situation, people can afford energy-efficient technologies and renewable energy consumption, like installing solar, wind, or geothermal power systems. So, a decrease in CO_2 emissions assures the achievement of sustainable economic development. Findings show consistency with Nasr-Allah et al. (2020), that stated that high employment rate signifies the high income and helps in bringing environmentally friendly improvement in standard of living. This life improvement reduces the CO_2 emission that threatens future economic development. So, with the increase in the employment level, sustainability can be developed in economic development.

5.1. Theoretical implication

The current study has made significant contributions to literature, and thereby, it guides academics on how they must act while conducting research about sustainable economic development. The study examines the impacts of eco-innovation, eco-investment, and green bonds with control factors of industrialisation, inflation, and employment rate on sustainable economic development. Here, the authors initiate to measure S.E.D. with the CO_2 emissions, the predictor of environmental pollution. In the previously conducted studies, the researchers have analysed the influences of eco-innovation, eco-investment, and green bonds with control factors of industrialisation, inflation, and employment rate on S.E.D. in different. The study contributes to the literature, for it chose Vietnam as the context of analysis of these factors' nexus.

5.2. Empirical implication

The present study has considerable significance in any emerging economy as its focus is on the universal issue of attaining sustainable economic development, while environmental pollution is a serious threat in this regard. The current study explains how CO_2 emissions can be controlled for sustainable economic development. It serves as a guideline to the economists and state power of a country that they must formulate trade, fiscal, or other economic policies to encourage eco-innovation in the country at both social and economic levels so that CO_2 emissions are reduced, and S.E.D. can be achieved. The research gives a suggestion that with effective financial policies, eco-investment must be encouraged. It will reduce CO_2 emissions and brings sustainability to economic development. Similarly, financial policy should promote green bond issuance in order to overcome CO_2 emissions and boost sustainable economic development. The study guides the policy-making authorities that they should establish the policies related to S.E.D. by using eco-innovation and eco-investment. The study guides them to manage industrialisation and inflation, manage energy patterns and control CO_2 emissions. Hence, S.E.D. can be achieved. The study recommends that the employment rate must be accelerated to reduce CO_2 emissions and enhance sustainability in economic development.

6. Conclusion

The study's objective was to scrutinise the role of eco-innovation, eco-investment, and green bonds in achieving sustainable economic development, and so it was also to check the role of industrialisation, inflation, and employment rate in S.E.D. For quantities information for eco-innovation, eco-investment, and green bonds with control factors of industrialisation, inflation, employment rate, CO_2 emissions, and sustainable economic development, the statistics of the Vietnamese economy were analysed. The results showed a positive association between eco-innovation, eco-investment, and green bonds with control factors of industrialisation, inflation, employment rate, and sustainable economic development. The results revealed that eco-innovation reduces CO_2 emissions. So, it is useful to achieve abundant quality resources, an active labour force, and a comfortable work environment contributing to sustainable economic development. The results stated that the eco-friendly investment encourages environmentally friendly practices within the country, which reduce CO_2 emissions with no break in economic activities. Hence, there is sustainable economic development. The study concluded that green bond issuance helps in investment in eco-friendly activities. As a result, there is a decrease in CO_2 emissions, and S.E.D. can be achieved. The results showed that when there is an increase in industrialisation or inflation, there is eco-friendly technological development and the adoption of eco-innovation. This reduces CO_2 emissions, and there is sustainable economic development. The financial prosperity as a result of the increasing employment rate encourages eco-friendly activities and reduces CO_2. So, there is sustainable economic development

There are several limitations of the study as well. The current study takes a limited factors like eco-innovation, eco-investment, and green bonds to evaluate sustainable economic development. The achievement of S.E.D. is a universal issue, and it requires many social, environmental, and economic initiatives. The study's major focus is only on environmental protection for sustainability in economic development. It is recommended to authors that they must increase the number of factors that can be useful in S.E.D. The present study measures S.E.D. with CO_2 emissions instead of using G.H.G. emissions as a perfect indicator of environmental quality. Future authors are recommended to use the factor G.H.G. emissions for S.E.D. This study confirms the relationship between eco-innovation, eco-investment, green bonds, industrialisation, inflation, employment rate and SED in light of evidence from a single country. For more valid results, authors should collect information about the understudy factors from multiple countries.

Disclosure statement

No potential conflict of interest was reported by the authors.

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