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RESEARCH ARTICLE

The influence of economic and non-economic determinants on the sustainable energy consumption: evidence from Vietnam economy

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Abstract

Maintaining ecological quality of energy use without compromising on economic growth has become the key research agenda of existing literature. Emerging economies are particularly facing this dual problem where they need to look in to the factors which impact sustainable energy consumption. The article, thus, aims to examine impact of economic and non-economic determinants on sustainable energy consumption in Vietnamese context. Factors such as industrialization, population growth, inflation, and employment rate are being considered as economic indicators and eco-innovation and political instability are being used as non-economic indicators. The study has taken secondary data from secondary sources such as Organization for Economic Co-operation and Development (OECD), the global economy, and World Development Indicators (WDI) from 1986 to 2020. The study has applied the Bayesian auto-regressive distributed lags (BARDL) model and the non-linear autoregressive distributed lag (NARDL) technique to check the association among variables. The results revealed that industrialization, population growth, inflation, employment rate, and eco-innovation have a positive linkage with SEC in Vietnam. The results also indicated that political instability has a negative association with SEC in Vietnam. In the light of results, it is obvious that government fiscal and monetary policies must be favorable to inflation so that sustainable energy can be introduced and started to consume. The study also conveys that the policymakers must take care of employment rate growth, for it can encourage sustaining energy consumption.

Keywords Industrialization · Population growth · Inflation · Employment rate · Economic determinants · Non-economic determinants · Eco-innovation · Political instability · Sustainable energy consumption

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Introduction

Energy is a key component of a nation's economic growth (EG). It keeps the social and economic engines running by giving them fuel. Energy consumption is crucial to a nation's ability to achieve greater economic development. Currently, achieving higher economic development alone is insufficient to ensure survival in the world and outperform other nations in global marketplaces (Andlib et al. 2012; Yan et al. 2018). However, it is also essential that sustainability must be built into economic development by maintaining the standards of the environment in which the economy and society both can flourish. The environment is harmed by traditional energy sources like fossil fuels. It causes climate change and thereby damages the natural resources quality and also the quality of welfare of living things (Andlib and Khan 2021; Yan et al. 2018).

Compared to fossil fuels, sustainable energy has the lowest potential for pollution, but it also reduces existing pollutants as it is produced. The crucial factors of economic and social development are secured for the future when renewable energy is utilized, and the nation's development can be made sustainable (Chie et al. 2021a; Chien et al. 2021a, b; Wang et al. 2019). Economic conditions like industrialization, inflation, and employment rate, population growth, non-economic factors like eco-innovation and political instability affect sustainable energy consumption. With industrialization, inflation, population growth, and employment rate, eco-innovation increase the need and demand for sustainable energy, the financial capacity to make an investment, and the ability to apply sustainable energy technologies (Bamisile et al. 2021; Chien et al. 2022c). At the same time, the implementation of sustainable energy technologies has to face challenges. Political instability refers to an unstable government structure and its inclination to collapse in a short time due to unstable political structures. Such a political condition does not allow the accomplishment of sustainable energy projects because it may cause many legal, economic, and financial challenges (Wang et al. 2021; Wirsbinna and Grega 2021).

The reason to choose Vietnam is that it has the capacity for sustainable energy. Thereby, the study investigates industrialization, inflation, population growth, employment rate, eco-innovation, and political instability and its linkage in the Vietnam economy (Jermsittiparsert 2021; Yemelyanov et al. 2021). Across Southeast Asia, this country has solar panels in use in large numbers. In recent years, it is observed that sustainable energy and electricity gauged from solar systems has been explored in the said economy. According to the sources, the country was engaged in 16,500 MW of sustainable energy in the year 2020 (Hannan et al. 2018; Ojogiwa 2021). Moreover, Vietnam is one of those top ten countries which had the highest potential to extracts energy from solar system in the year 2020. With these statistics, the authors predict that wind energy might reach up to 311 GW; hence, it may become the finest source of energy. Also, Vietnam holds a predominant position due to which it might become the world leader in novel sustainable energy solution. As the country has significant position, thereby, it shows more commitment to make investments in sustainable energy. According to sources, in 2014, the country was able to produce 4 MW of installed solar energy for electricity production. Currently, the share of Vietnam of total renewable energy in electricity generation is 0.32% (Hartani et al. 2021; Oppong-Tawiah et al. 2020; Shibli et al. 2021).

The figure currently is low; however, the country still managed to get success in generating over 7.4 GW of rooftop solar electricity in the last decade. Ten percent of the country's total electricity is produced using sustainable energy. According to figures from 2018, the country's economy is growing at 7%, and population growth is also present (Nguyen et al. 2021; Zhao et al. 2021, 2022). Due to increase in economic growth, the excessive use of fossil fuel uprises; hence, the situation is unfavorable for well-beings. As a result, the development of the country in the future is threatened. Due to the positive effects of sustainable energy on the environment, society, and the economy, renewable energy usage has now become imperative (Li et al. 2022; Nong et al. 2020). The objective of the study is to explore the impacts of economic conditions like industrialization, inflation, employment rate, population growth, non-economic factors like eco-innovation, and political instability on SEC.

Since the consumption of sustainable energy is critical to create sustainability in a country's development, there, it has become concern for academia and researchers. And several authors have written on SEC. Despite this, the current study makes great contributions to literature. (1) In the previous literature, the role of industrialization, inflation, employment rate, population growth, eco-innovation, and political instability in SEC has been examined but through different research surveys. This study presents a simultaneous analysis of the impacts of industrialization, inflation, employment rate, population growth, eco-innovation, and political instability on SEC. So, it adds to the literature. (2) In the previous literature, most authors have talked about sustainable energy from a production point of view while analyzing the factors like Industrialization, inflation, employment rate, population growth, eco-innovation, and political instability. This study contributes to the literature for analyzing the impacts of industrialization, inflation, employment rate, population growth, eco-innovation, and political instability on SEC. (3) Third, the issue of the increasing need for energy and environmental problems raised by non-renewable energy consumption has been observed in Vietnam. There has always

been a need to address SEC. The present study initiates to address the role of industrialization, inflation, employment rate, population growth, eco-innovation, and political instability in the SEC.

The rest of the paper is composed of the following parts. The next portion throws light on the relationship between industrialization, inflation, employment rate, population growth, eco-innovation, political instability, and SEC with the literature review. The third portion is the description of the econometric and statistical methods applied to analyze the variables and their relations. After analysis, the results of the research are found, and these results are compared with the previous studies' findings. Then, study implications are given, and the implications are followed by the study conclusion and limitations.

Literature review

The consumption of renewable energy contributes to the preservation of energy resources because it is helpful in meeting of additional energy sources demands and reducing the consumption of fossil fuels and conventional sources that are already scarce (Khattak et al. 2021; Mombeuil 2020; Safdar et al. 2022). Additionally, the implementation of sustainable energy technologies, such as biomass, biofuel, solar, wind, and hydroelectricity, protect the environment and resources (the productivity of the environment), including crops, timber, fish, food, animals, birds, and human resources. All of these advantages of SEC help the economy develop sustainably (Ali et al. 2022; Jose et al. 2020; Sohail et al. 2022). Many economic and non-economic variables have the potential to contribute to the implementation of SEC or may create challenges in this way. The present article examines the influences of economic conditions like industrialization, inflation, employment rate, population growth, and non-economic factors like eco-innovation and political instability on SEC. The role of industrialization, inflation and employment rate, population growth, eco-innovation, and political instability affecting SEC has been a debate in the existing literature separately. But the said study investigates the relationship between industrialization, inflation, employment rate, population growth, eco-innovation, political instability, and the SEC jointly (Abdul Hamid et al. 2020; Ainou et al. 2022).

Li et al. (2019) investigate the influences of Industrialization and urbanization on SEC. The authors collected panel data for Industrialization, urbanization, and SEC from 30 provinces of china over the period 2006–2015. For the evaluation of the data and relationship among factors, the fixed effect model was applied. The results revealed that industrialization over the greater area enhances the awareness of technological advancements and emerging business concepts among the public. As a result of this awareness, people prefer SEC. Kristiansen et al. (2019) examine the industrialization role in SEC. The study theme is supported by evidential data from Europe, the USA, and China. The study reveals that the increase in industrialization encourages SEC. In these states, solar-powered zero-energy buildings are being encouraged for industrialization. There is a positive association between industrialization and SEC. Majeed and Tauqir (2020) examine the influences of industrialization and urbanization on CO_2 emission and SEC. The panel data were acquired from 156 nations with the differentiation of income groups for the time of 1990–2014 with the help of the first and second generation tests. The dynamic GMM, CCEMG, and dynamic CCEMG estimators were applied for analysis. The study posits that Industrialization is positively linked to SEC. The development of Industrialization within the country, with financial development and improvement in management efficiency, encourages SEC so that economic development can be sustained. Rahman et al. (2021) integrate the relationship between industrialization, EG, and CO_2 emissions and sustainable economic development. The information for the abovementioned factors was acquired from the newly industrialized countries for the time of 1979 – 2017. With the panel co-integration estimation technique, DOLS, FMOLS, and PMG estimators were applied. The study implies that with the encouragement of industrialization, people have the awareness and capacity to move towards SEC. Hence, there is a positive association between industrialization and SEC (Bai et al. 2022; Chien 2022a; Lan et al. 2022).

A study conducted by Amri (2019) integrates the relationship between inflation, trade, and SEC. The authors employed GMM dynamic panel data models and collected data for the factors of interest and their relationship from 72 countries over the period of 1990–2012. According to the research findings, inflation has a positive association with SEC. Inflation accelerates the activity of the economy. It creates ways how to secure energy for the future by applying energy-efficient economic procedures. So, inflation has a positive relation to SEC. Yahya and Rafiq (2019) examine the impacts of inflation, innovativeness, trade openness, tax attractiveness, GDP, financial liberalization, and political stability on SEC. The system GMM estimator was employed to reduce the endogeneity difference in the model. A broad sample based on 85 countries was analyzed. The results show that when the economy comes into an inflationary period, the profits of business units' increase, and economic opportunities arise. In this situation, these businesses can adopt eco-innovation, energy transition, and energy efficiency. So, inflation positively influences SEC. Alola et al. (2019) investigate the relationship between inflation rate, sustainable energy production, environmental quality, and food production. For this purpose, research

was conducted on 16 Mediterranean countries spanning the period 1995–2014 on an annual basis. For the empirical analysis, the dynamic ARDL approach was used. The results confirm that in inflation, where the prices of the products rise, profits increase, and there is more money to be invested in the economy, there is a trend to utilize sustainable energy. Deka and Dube (2021) investigate the association between inflation, exchange rate, and SEC. The ARDL bounds test approach was applied, and quantitative data for inflation, exchange rate, and SEC was acquired from Mexico for the years between 1990 and 2019. The study claims that with the increase in financial development as a result of inflation and exchange rate rise, SEC within the country. Sadiq et al. (2022a) and Sadiq et al. (2022c) analyzed the relation of economic factors like inflation, EG, and population to SEC with evidence from China from 1981 to 2019. The results indicate that inflation has a positive contribution to SEC.

Dong et al. (2018) analyze the association between economic and population growth with SEC across regions. The panel data for economic and population growth impacts on SEC was from 128 countries for the time of 1990–2014. The CCEMG estimator was applied to check the relation. The results showed a significant association between population growth with sustainable economic development both at the regional and world level. However, population growth causes CO_2 emissions, but capital formation and economic development as a result of population growth play a significant role in encouraging SEC, which can overcome environmental pollution (Chien et al. 2022a; Liu et al. 2022a; Wangzhou et al. 2022). Rahman and Velayutham (2020) check the relationship between EG and population growth with SEC. A panel dataset for the EG, population growth, and energy consumption was from 5 South Asian countries covering the years 1990–2014. In order to find long-term cointegration among the factors, the authors employed Kao's (1999) tests and Pedroni's (1999, 2004). Moreover, DOLS and FMOLS were applied. The study findings reveal a positive link between population growth and SEC. With the rise in population growth, the need for energy arises; as fossil fuels are an insufficient and unsatisfactory source of energy, there is a struggle to use sustainable energy like wind, solar, geothermal power, etc. da Silva et al. (2018) analyze the population growth impacts on renewable energy consumption for sustainable energy future. Sub-Saharan Africa is the spot of empirical analysis for the study. With the help of the panel data technique, the panel-ARDL model, the information for the variables were acquired from 1990 to 2014. The results convey that to a specific point, the increase in population growth enhances energy consumption irrespective of sustainability and but after a point, it encourages the use of SEC. Sharma et al. (2021) investigate the population growth, capita income, and life expectancy linkage with CO_2 emissions and sustainable energy with evidence from South and Southeast Asia from 1990 to 2015. The results of CS-ARDL showed that population growth motivates the economy to apply SEC to secure energy and protect the environment. Hence, population growth positively influences sustainable economic development.

Majid (2020) examines the influences of employment rate on renewable energy for sustainable development. The authors take the Indian economy for the empirical investigation of factors under study, for India is one of the most populous countries, and it has attained a market that is mostly based on renewable energy consumption and moving towards sustainable development. The findings showed that the employment rate has a positive relation to SEC. The rise in the employment level enhances the need for clean and sustainable energy. The rising employment rate develops the capacity to implement SEC for providing labor to sustainable energy systems and increasing financial strength (Chien et al. 2022b; Chien 2022b; Sadiq et al. 2022b). In a research study on the significance of SEC for economic wellbeing, Haseeb et al. (2019) analyze the role of employment rate in SEC. The empirical quantitative data for the understudy factors were acquired from Malaysia for the time of 1980–2016. For the deep analysis of the factors' relations, the autoregressive distributed bound testing approach was applied. It was indicated by study findings that the increase in the employment rate means economic prosperity. When an economy is making development, the production of sustainable energy like wind power, solar energy, bioenergy, hydroelectricity, and geothermal power can be facilitated. It enhances SEC within the country. So, there is a positive role of employment rate in SEC (Sun et al. 2021, 2022). Benedek et al. (2018) evaluate sustainable energy sources like wind, solar, and biomass and checks the role of employment rate. The necessary information for the assessment of the relationship among the variables of interest was acquired from Covasna County in Romania, and the research was stretched over the years during 2000–2015. The study proclaims that the rural areas where the employment rate is high, SEC programs can be implemented easily. Likewise, the study of Ntanos et al. (2018) was about the employment rate, EG, and SEC. The evidence was collected from 25 European countries for the time of 2007–2016. The study confirms that the employment rate is positively linked to SEC.

Su et al. (2021) check the role of eco-innovation and fiscal decentralization along with political risks in sustainable energy use. The authors investigated eco-innovation, fiscal decentralization along, and sustainable energy use in seven OECD nations, and this investigation stretched over the period of 1990–2018. Analytical techniques such as Banerjee and Carrion-I-Silvestre (2017), CS-ARDL, and CCEMG were used for empirical analysis of the relation. The investigation highlights that the incorporation of eco-innovation into economic activities and social practices discourages

the use of non-renewable energy, which can create environmental issues afterward. It encourages the application of sustainable energy like bioenergy, solar power, wind power, and hydroelectricity which have minimum environmental issues. So, eco-innovation is positively linked to sustainable economic development. Li et al. (2020) check the eco-innovation as well as energy productivity as the determinants of SEC. The factors like eco-innovation, energy productivity, and SEC were examined in OECD countries for the years from 1990 to 2017. The Durbin Hausman group mean co-integration test and augmented mean group (AMG) with CS-ARDL model were applied. The results showed that the purpose of eco-innovation is to secure the environment and save the health of living beings from adverse impacts of human social and economic activities. So, eco-innovation encourages the use of sustainable energy, which can assure a sustainable environment and natural resources. The study of Khan et al. (2020) enumerates the influences of eco-innovation, energy price, R&D expenditures, and financial development on SEC. Westerlund and Edgerton's panel co-integration and augmented mean group (AMG) to find results from panel data set from G7 countries from 1995 to 2017. The results prove that eco-innovation significantly contributes to SEC because it provides financial investment in sustainable energy projects for its environmentally friendly aspect. Huang et al. (2022) throw light on how effective eco-innovation is in promoting cleaner and sustainable energy. After a significant empirical investigation of OECD economies, the study gives the idea that eco-innovation enhances SEC.

Sustainable energy technologies like solar, wind, hydropower, and biomass provide financial, environmental, and developmental issues. But the adoption of sustainable energy technologies has to face several barriers within the country (Liu et al. 2022b; Tan et al. 2021). Ghimire and Kim (2018) examine social, policy and political, economic, administrative, technical, and geographic barriers to sustainable energy technologies like solar, wind, hydropower, and biomass in developing countries like Nepal. The study posits that when there is political instability within a country, there is a lack of quick and effective decision-making and frequent changes in the policies. So, the adoption of sustainable energy technologies becomes difficult. Hence, there is a negative relationship between political instability and sustainable energy technologies. Surroop and Raghoo (2018) investigate the adoption of SEC in African Islands. The study highlights that the African island states, including Cape Verde, Comoros, São Tomé and Príncipe, Guinea-Bissau, Mauritius Madagascar, and Seychelles, overwhelmingly depend on fossil fuel energy. Renewable energy is not much likely to be developed. Among African islands, the economic and demographic characteristics are different, and the power sector is also complex due to specific challenges. There is a lack of sustainable energy in Guinea-Bissau and Madagascar because of political instability. Hence, political instability natively influences SEC. Aydin (2022) examines the relationship between political stability, EG, and renewable energy consumption for tourism. The data related to political stability, EG and renewable energy consumption for tourism were collected from Turkey during 1996–2018. For this, the author's employed a long-run estimator, co-integration test, and causality test for the robust results. The results showed that because of the political instability, the ecological friendly projects which are to promote sustainable energy are not possible to be accomplished, and there is a lack of SEC. So, political instability is negatively linked to SEC.

Research methodology

The article examines the impact of industrialization, population growth, inflation, employment rate, eco-innovation, and political instability on SEC in Vietnam. The study has taken secondary data from secondary sources such as OECD, the global economy, and WDI from 1986 to 2020. The study has established the equation using understudy constructs given as under:

$$SEC_t = \alpha_0 + \beta_1 IND_t + \beta_2 INF_t + \beta_3 PG_t + \beta_4 EMR_t + \beta_5 ECI_t + \beta_6 PIN_t + e_t \quad (1)$$

where SEC is the sustainable energy consumption, t is the time period, IND is the industrialization, INF is the inflation, PG is the population growth, EMR is the employment rate, ECI is the eco-innovation, PIN is the political instability.

The study has used SEC measured with renewable energy consumption (REC) percentage of total energy consumption. Moreover, the study has taken six predictors such as industrialization measured with industry value added (percentage of GDP), inflation measured with consumer price (annual percentage), population growth measured with growth (annual percentage), employment rate measured with employment in industry (percentage of total employment), eco-innovation measured with eco-innovation index and political instability measured with political instability index. These variables and measurements are given in Table 1.

The study has run the descriptive statistics that show the complete details of the variables. In addition, the study also runs the year-wise descriptive statistics that show the years-wise changes in the variables. Moreover, the study has also run the correlation matrix that shows the directional linkage among variables. Furthermore, the study also runs the augmented Dickey-Fuller (ADF) test as well as Phillips–Perron (PP) test to check the stationarity of the variables. The equation is mentioned as under:

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

Moreover, the study also runs the (Westerlund and Edgerton 2008) co-integration test to check the co-integration among the variables. The null hypothesis shows no

Table 1 Measurements of variables

S#	Variables	Measurement	Sources
01	Sustainable energy consumption	REC (percentage of total energy consumption)	WDI
02	Economic determinants	Industry value added (percentage of GDP)	WDI
		Consumer price (annual percentage)	WDI
		Population growth (annual percentage)	WDI
		Employment in industry (percentage of total employment)	WDI
03	Non-economic determinants	Eco-innovation index	OECD
		Political instability index	The global economy

co-integration exists and vice versa. The equations for the test are mentioned as under:

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

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

In the above equation, $\widehat{\boldsymbol{\varphi}}_{\boldsymbol{i}}$ represents the estimate against $\hat{\sigma_i}$ standard error. While, $\hat{r^2}_i$ represents its long-run measured variance. In addition, $\boldsymbol{\varphi i}\,(\boldsymbol{L}) = \mathbf{1} - \sum \boldsymbol{\varphi}_{\boldsymbol{ij}} \boldsymbol{L}^{\boldsymbol{j}}$ represents the scalar polynomial with L lag length. Finally, the ρ_i presents the factor loading parameters vector.

The study also runs the ARDL model because ARDL is suitable when some constructs have no unit root at I(0), and others have no unit root at I(1). It also controls the effects of autocorrelation on the estimations (Zaidi and Saidi 2018). It also provides both short as well as a long-run linkage among constructs (Nazir et al. 2018). The equation for the test is mentioned as under:

$$\begin{aligned}\Delta SEC_t = {} & \alpha_0 + \sum \delta_1 \Delta SEC_{t-1} + \sum \delta_2 \Delta IND_{t-1} + \sum \delta_3 \Delta INF_{t-1} \\ & + \sum \delta_4 \Delta PG_{t-1} + \sum \delta_5 \Delta EMR_{t-1} + \sum \delta_6 \Delta ECI_{t-1} \\ & + \sum \delta_7 \Delta PIN_{t-1} + \varphi_1 SEC_{t-1} + \varphi_2 IND_{t-1} + \varphi_3 INF_{t-1} \\ & + \varphi_4 PG_{t-1} + \varphi_5 EMR_{t-1} + \varphi_6 ECI_{t-1} + \varphi_7 PIN_{t-1} + \varepsilon_t\end{aligned} \tag{5}$$

In addition, the article has also run the Bayesian inference analysis, presumed that the observed data is fixed while the valuation parameters are random. Hence, it works on Bayesian regarding prior distribution results by utilizing later information related to model parameters from observed information (Salakpi et al. 2022). Moreover, the Bayesian "general" linear model (GLM) regression is mentioned as under:

$$Y_t \sim N + \beta^T X_t, \delta^2 I \tag{6}$$

In Eq. (6), Y_t represents the SEC drawn from Gaussian distribution. In contrast, the X_t is the matrix of predictors. Moreover, β^T shows the transposed weight matrix. In contrast, δ^2 shows the variance, and I represent the identity matrix.

The prior distribution shows the pre-existing data or information related to parameters imitative from expert knowledge. Thus, ordinary least squares (OLS) provided weak results, and it is highly suggested by past studies that Bayesian inference analysis is necessary for reliable results (Ngoc and Awan 2022). It also created the posterior distribution from a probability distribution with the help of prior observed data. The equation is given below:

$$P(\beta/Y_t, X_t) = \frac{\mathrm{P}(Y_t/\beta, X_t) * \mathrm{P}(\beta/X_t)}{\mathrm{P}(Y_t/X_t)} \tag{7}$$

In Eq. (7), $\mathrm{P}(Y_t/\beta, X_t)$ represents the data likelihood, and $\mathrm{P}(\beta/X_t)$ represents prior probability related to the model parameters and $\mathrm{P}(Y_t/X_t)$ represents the normalization constant. Moreover, the study has also used the adaptive random-walk Metropolis–Hastings algorithm to avoid spurious convergence and confirm the association among SEC, industrialization, inflation, employment rate, population growth, eco-innovation, and political instability.

In addition, the article also investigates the asymmetric association between eco-innovation, political instability, and SEC. Thus, the nonlinear function among variables is given as under:

$$SEC = f(IND, INF, PG, EMR, ECI^+, ECI^-, PIN^+, PIN^-) \tag{8}$$

Thus, the partial sum of negative and positive alterations in eco-innovation and political instability are mentioned as under:

$$ECI^+ = \sum_{i=1}^{t} \Delta ECI_i^+ = \sum_{i=1}^{t} \max(\Delta ECI_i 0) \tag{9}$$

$$ECI^- = \sum_{i=1}^{t} \Delta ECI_i^- = \sum_{i=1}^{t} \min(\Delta ECI_i 0) \tag{10}$$

$$PIN^+ = \sum_{i=1}^{t} \Delta PIN_i^+ = \sum_{i=1}^{t} \max(\Delta PIN_i 0) \tag{11}$$

$$PIN^- = \sum_{i=1}^{t} \Delta PIN_i^- = \sum_{i=1}^{t} \min(\Delta IN_i 0) \tag{12}$$

Hence, the present study has established the nonlinear ARDL model equation using positive and negative alterations in eco-innovation and political instability. This equation is mentioned below:

$$\begin{aligned} SEC_t = {} & \alpha_0 + \sum \delta_1 SEC_{t-1} + \sum \delta_2 \Delta IND_{t-1} + \sum \delta_3 \Delta INF_{t-1} + \\ & \sum \delta_4 \Delta PG_{t-1} + \sum \delta_5 \Delta EMR_{t-1} + \sum \delta_6 \Delta ECI^{+}_{t-1} + \sum \delta_7 \Delta ECI^{-}_{t-1} + \\ & \sum \delta_8 \Delta PIN^{+}_{t-1} + \sum \delta_9 \Delta PIN^{-}_{t-1} + \varphi_1 SEC_{t-1} + \varphi_2 IND_{t-1} + \varphi_3 INF_{t-1} + \\ & \varphi_4 PG_{t-1} + \varphi_5 EMR_{t-1} + \varphi_6 ECI^{+}_{t-1} + \varphi_7 ECI^{-}_{t-1} + \varphi_8 PIN^{+}_{t-1} + \varphi_9 PIN^{-}_{t-1} + \varepsilon_t \end{aligned} \tag{13}$$

Research findings

The study has run the descriptive statistics that show the complete details of the variables. The results indicated that the SEC mean value was 50.960%, while IND average value was 3.960%, and the INF mean value was 5.947%. In addition, the results also indicated that the PG mean value was 1.340%, while EMR average value was 13.935%, ECI mean value was 0.574%, and the PIN mean value was 0.293%. Table 2 shows these outcomes.

In addition, the study also runs year-wise descriptive statistics that show the years-wise changes in the variables. The results indicated the highest SEC was in 1986, while the largest industrialization was in 2020, and the highest inflation was recorded in 2011. In addition, the results also showed that the highest PG was recorded in 1986, while the highest EMR was in 2020, the highest ECI was in 2019, and the highest PIN was recorded in 2020. Table 3 shows these outcomes.

Moreover, the study has also run the correlation matrix that shows the direction linkage among variables. The results revealed that industrialization, population growth, inflation, employment rate, and eco-innovation have a positive linkage with SEC in Vietnam. The results also indicated that political instability has a negative association with SEC in Vietnam. Table 4 shows these outcomes.

Furthermore, the study also runs the ADF test as well as the PP test to check the stationarity of the variables. The findings indicated that the SEC, IND, ECI, and PIN are stationary at a level while INF, PG, and EMR are stationary at first difference. Table 5 shows these outcomes.

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
SEC	35	50.960	19.594	18.65	83.242
IND	35	3.960	0.650	2.901	5.037
INF	35	5.947	4.508	−1.710	23.115
PG	35	1.340	0.495	0.905	2.268
EMR	35	13.935	4.925	8.570	24.839
ECI	35	0.574	0.074	0.453	0.708
PIN	35	0.293	0.211	−0.088	0.541

Moreover, the study also runs the (Westerlund and Edgerton 2008) co-integration test to check the co-integration among the variables. The results indicated that the *t* values are larger than 1.96 and the probability values are lower than 0.05. The results indicated that co-integration exists. Table 6 shows these outcomes.

The results related to the ARDL revealed that industrialization, population growth, inflation, employment rate, and eco-innovation positively link SEC in Vietnam in the short run. The results also indicated that political instability has a negative association with SEC in Vietnam in the short run. Table 3 shows these outcomes (Table 7).

The results related to the ARDL model revealed that industrialization, population growth, inflation, employment rate, and eco-innovation have a positive linkage with SEC in Vietnam in the long run. The results also indicated that political instability has a negative association with SEC in Vietnam in the long run. Table 8 shows these outcomes.

The results revealed that industrialization, population growth, inflation, employment rate, and eco-innovation have a positive linkage with SEC in Vietnam. The results also indicated that political instability has a negative association with SEC in Vietnam. Moreover, the acceptance rate of 0.382 is higher than the optimal acceptance rate of 0.234, while the parameters of standard deviation are small, and the Monte Carlo chain standard errors (MCSE) are near to the decimal one. Therefore, Bayesian inference is valid. Table 9 shows these outcomes.

The results of NARDL revealed that industrialization, population growth, inflation, employment rate, and eco-innovation have a positive linkage with SEC in Vietnam. The results also indicated that political instability has a negative association with SEC in Vietnam. Moreover, the results also exposed that eco-innovation, both positive and negative, have a positive association with SEC, while political instability, both positive and negative, have a negative association with SEC. Table 10 shows these outcomes.

Table 3 Descriptive statistics by years

	SEC	IND	INF	PG	EMR	ECI	PIN
1986	83.242	2.901	5.651	2.268	8.570	0.453	−0.076
1987	81.343	2.920	5.669	2.235	8.682	0.460	−0.088
1988	79.444	2.938	5.686	2.202	8.795	0.467	−0.028
1989	77.545	3.109	5.704	2.172	8.907	0.474	−0.021
1990	76.082	3.209	5.721	2.139	9.019	0.481	−0.013
1991	75.637	3.299	5.738	2.108	8.780	0.488	−0.002
1992	74.702	3.109	5.756	2.062	9.100	0.496	0.091
1993	70.813	3.357	5.773	1.979	9.410	0.503	0.079
1994	67.986	3.390	5.791	1.851	9.620	0.510	0.104
1995	65.126	3.454	5.808	1.695	9.820	0.517	0.128
1996	62.866	3.517	5.675	1.534	10.130	0.524	0.153
1997	60.792	3.580	3.210	1.390	10.400	0.531	0.177
1998	59.499	3.644	7.266	1.266	9.130	0.538	0.202
1999	59.567	3.707	4.117	1.171	9.840	0.545	0.227
2000	57.730	3.770	−1.710	1.100	10.120	0.553	0.251
2001	56.140	3.834	−0.432	1.036	11.150	0.560	0.276
2002	52.200	3.897	3.831	0.976	11.700	0.567	0.301
2003	50.830	3.960	3.235	0.937	12.970	0.574	0.325
2004	45.770	4.024	7.755	0.921	13.730	0.581	0.350
2005	44.150	4.087	8.285	0.923	14.780	0.588	0.375
2006	44.250	4.150	7.418	0.932	15.900	0.595	0.399
2007	41.900	4.214	8.344	0.943	16.090	0.603	0.424
2008	39.260	4.277	23.115	0.960	16.440	0.610	0.448
2009	36.970	4.340	6.717	0.979	16.970	0.617	0.473
2010	34.580	4.404	9.207	1.000	17.250	0.657	0.498
2011	36.320	4.467	18.678	1.022	16.560	0.618	0.492
2012	37.900	4.530	9.095	1.042	16.840	0.627	0.507
2013	37.350	4.594	6.593	1.053	16.960	0.637	0.508
2014	36.640	4.657	4.085	1.054	17.500	0.646	0.513
2015	30.330	4.720	0.631	1.045	19.320	0.655	0.518
2016	22.480	4.784	2.668	1.034	20.770	0.665	0.522
2017	25.020	4.847	3.520	1.020	21.810	0.666	0.527
2018	21.810	4.910	3.540	0.994	22.560	0.687	0.532
2019	18.650	4.974	2.796	0.954	23.280	0.708	0.536
2020	18.678	5.037	3.221	0.905	24.839	0.690	0.541

Table 4 Matrix of correlations

Variables	SEC	IND	INF	PG	EMR	ECI	PIN
SEC	1.000						
IND	0.992	1.000					
INF	0.061	0.040	1.000				
PG	0.868	−0.854	−0.069	1.000			
EMR	0.959	0.955	0.040	−0.717	1.000		
ECI	0.994	0.993	0.030	−0.853	0.957	1.000	
PIN	−0.977	0.977	0.123	−0.913	0.902	0.976	1.000

Table 5 Unit root test

Series	ADF		PP	
	Level	First difference	Level	First difference
SEC	−3.244***	—	−4.899***	—
IND	−4.902***	—	−3.662***	—
INF	—	−2.776***	—	−3.292***
PG	—	−3.217***	—	−3.121***
EMR	—	−3.222***	—	−4.102***
ECI	−2.900***	—	−4.552***	—
PIN	−3.192***	—	−5.211***	—

Table 6 Co-integration test results

Model	No shift		Mean shift		Regime shift	
	Test stat	*p* value	Test stat	*p* value	Test stat	*p* value
LM_{τ}	−3.112	0.000	−4.292	0.000	−5.663	0.000
LM_{φ}	−3.321	0.000	−4.100	0.000	−5.902	0.000

Table 7 Short-run coefficients

Variable	Coefficient	Std. error	*t* statistic	Prob
D (IND)	0.541	0.114	4.746	0.000
D (INF)	0.642	0.122	5.262	0.000
D (PG)	4.635	1.038	4.465	0.000
D (EMR)	1.752	0.182	9.626	0.000
D (ECI)	1.897	0.534	3.552	0.011
D (PIN)	−0.202	0.032	−6.313	0.000
CointEq (−1)*	−1.432	0.221	−6.479	0.000
R-squared	0.567	Mean dependent var		−0.042
Adjusted *R*-squared	0.540	S.D. dependent var		2.117

Discussions

The study findings revealed that industrialization is positively linked to SEC. These results are supported by the past study of Azam et al. (2021), which examines the role of industrialization in SEC. This study proclaims that when industrialization is being promoted in rural areas, the rural population also has the knowledge of innovative energy technologies, which may cause minimum environmental pollution. It motivates them to adopt sustainable energy instead of fossil fuels for carrying on social and economic activities. Thus, the past study confirms that Industrialization has a positive linkage with SEC. These results are also in line with the past studies of Haroon et al. (2021) and Shahzad et al. (2021), throwing light on the industrialization contribution to SEC. According to this study, in the areas where industrialization is growing rapidly, innovative eco-logical-friendly technologies and techniques are getting popular. In these circumstances, the use of sustainable energy and the ways to use energy efficiently get promoted. So, industrialization has a positive and significant relation to SEC.

Table 8 Long-run coefficients

Variable	Coefficient	Std. Error	*t* statistic	Prob
IND	3.012	0.934	3.224	0.011
INF	2.954	0.344	8.587	0.000
PG	1.267	0.231	5.485	0.000
EMR	4.220	1.902	2.219	0.029
ECI	2.332	1.001	2.329	0.021
PIN	−1.336	0.523	−2.554	0.019
C	0.843	0.299	2.819	0.016

It has also been shown by the study results that inflation is positively linked to SEC. These results are supported by the past study (Khan et al. 2022). This previous study posits that during inflation within the economy, there are developmental activities being planned and carried out in the country because inflation raises funds. In this situation, sustainable energy like wind, solar, biomass, and hydropower

Table 9 Bayesian analysis results

Variables	Mean	Std. Dev	MCSE	Prob. of mean > 0	Interval
IND	3.875	0.743	0.033	0.901	0.432, 1.102
INF	5.664	0.764	0.058	1	0.902, 1.091
PG	5.253	0.754	0.056	1	1.322, 2.542
EMR	7.910	0.942	0.072	1	1.535, 3.431
ECI	2.102	0.291	0.031	0.891	0.125, 1.741
PIN	-8.773	0.919	0.086	1	0.146, 1.542
Intercept	− 52.231	6.911	0.402	1	1.438, 2.652
e.ME Sigma2	0.699	0.132	0.003		1.129, 3.656
					Acceptance rate = 0.382

is convenient to be developed within the economy. These results are also in line with the studies of Ahmad et al. (2021) and Kamarudin et al. (2021), which state that during an inflationary period, when the market prices are going upward and there is a sudden rise in the marketing of products and services, the firms are motivated to expand their businesses. In this situation, when the firm requires more energy ad has the ability to apply sustainable energy technologies, the use of sustainable energy increases within the economy. So, the previous studies also confirm that inflation positively contributes to SEC.

The results indicated that the employment rate is positively linked to SEC. These results are in line with the past study of Hosseini (2020), which states that the employment rate is associated with the financial strength of the countrymen and their living style. The increase in the employment rate enhances the financial strength of the people and improves their living. These people turn from fossil fuel energy to sustainable energy to meet their needs because of its environmental and health benefits. So, increasing the employment rate encourages SEC within the country. These results are also in line with Ervural et al. (2018), which posit that the increase in employment rate enhances the productivity level of the businesses. The increase in the business earnings allows the firms to bring eco-innovation in their resources and functioning to make their performance sustainable. In this situation, there is a transition from non-renewable energy to SEC. That is why the employment rate increases SEC.

Table 10 Nonlinear ARDL results

Variables	Coefficients	Std. err	*t* statistics
C	0.576	0.261	2.207
SEC (− 1)	0.253	0.021	12.048
IND (− 1)	0.954	0.320	2.981
INF (− 1)	1.353	0.402	3.366
PG (− 1)	2.901	0.763	3.802
EMR (− 1)	1.904	0.432	4.407
ECI − P (− 1)	0.732	0.104	7.038
ECI − N (− 1)	0.892	0.209	4.268
PIN-P (− 1)	− 0.442	0.103	− 4.291
PIN-N (− 1)	− 1.883	0.309	− 6.094
Adj. *R* square	0.664		
F statistics	50.172		
Prob. (*F* statistics)	0.009		

The results indicated that population growth is positively linked to SEC. These results are supported by the previous study of Tripathy et al. (2018), which debates the role of population growth in SEC. This previous research study claims that he states where the population strength is high, the formation of human capital is higher. The improvement in human capital is helpful in employing ecological-friendly technologies and technical processes. So, the use of sustainable energy, which is required in energy-efficient technologies, is possible to apply. These results are also in line with Namany et al. (2019). This previous article checks population growth impacts the energy pattern applied by the economic actors. The study explains that the greater population within the country facilitates the firms operating sustainable energy production activities to hire more labor for this work. The increase in the production of sustainable energy enhances the availability of sustainable energy, and business firms have access to clean energy. Thus, the use of sustainable energy increases, giving second importance to fossil fuel consumption. These previous studies support the current article for their claim that the increase in population growth leads to SEC.

The study also found that eco-innovation is positively linked to SEC. These results are supported by Ji et al. (2021). The study states that the firms which have the policy to maintain eco-innovation in the different economic sectors apply energy-efficient technologies which require renewable energy and utilize those energy resources which leave no harmful wastes cost less, and give higher productivity. These firms apply solar power, wind energy, biomass, and hydro-electricity as these may run the innovative technologies and have all the mentioned benefits. Thus, eco-innovation contributes to SEC. These results agree with Rutkowska et al.

(2021) which highlight that the firms which are conscious of the public ecological requirements and have the intention to provide ecological-friendly products and services apply eco-innovation while managing resources and business processes. Ecological friendly changes in resources and processes require sustainable energy. Hence, eco-innovation increases SEC.

The results indicated that political instability is negatively linked to SEC. These results are in line with the past study of Surroop and Raghoo (2018), which states that the change in the government authorities and disagreement among the political authorities create disturbance and distress in the economy. Though many ecological friendly programs have been planned, their actual execution becomes impossible. That is why, during political instability, SEC becomes slow or impossible. These results also agree with Filipović et al. (2018), which shows that when there is instability in the government, and the policies of authorities are shattered, there may raise challenges in executing sustainable energy production. The lack of available sustainable energy restricts the increasing use of sustainable energy. These results are also in line with Bano et al. (2019), which argue that political instability impacts sustainable energy. The study posits that when there is instability in the government structure, it is feared to collapse soon. This instability and fear of change of power and policies create challenges to sustainable energy production and consumption. So, the previous study confirms the present one in the sense that it also shows a negative link between political instability and SEC.

Theoretical implications

Academics and researchers can learn much from this study because it has a significant contribution to sustainability literature. The current study examines the influences of economic factors like industrialization, inflation, population growth, and employment rate and non-economic factors like eco-innovation and political instability on SEC. It is one of the initial attempts in the literature that the impacts of industrialization, inflation, population growth, employment rate, co-innovation, and political instability on SEC have been analyzed at the same time. The past literature has little attention to SEC. The current study also contributes to the literature for analyzing the role of industrialization, inflation, population growth, employment rate, co-innovation, and political instability in SEC in Vietnam.

Empirical implications

The present study is significant to all emerging economies for SEC; the focal point in this study is essential for the countries to attain sustainable development. It has many empirical implications. The study guides the economists, firms' management, and government on how SEC can be encouraged. The study suggests that government policies must be made to increase Industrialization to encourage SEC. The study also recommends that government fiscal and monetary policies must be favorable to inflation so that sustainable energy can be introduced and started to consume. The study also conveys that the policymakers must take care of employment rate growth, for it can encourage sustaining energy consumption. The study provides guidelines to the regulators while establishing regulations related to SEC by promoting industrialization and removing political instability. The continuous increase in the population must be effectively managed in order to encourage SEC. The study provides a guideline that economists and firm must improve their policies for eco-innovation adoption as it can promote SEC. The study also recommends that the government they must avoid political instability by implementing sustainable energy programs.

Conclusion

The aim of the study was to check the impacts of economic factors, such as industrialization, inflation, population growth, and employment rate, on SEC. And it was also to analyze the role of non-economic factors like co-innovation and political instability in SEC. The authors investigated industrialization, inflation, population growth, employment rate, co-innovation, political instability, and SEC in Vietnam. The results showed that there is a positive association between industrialization, inflation, population growth, employment rate, co-innovation, and SEC. The results showed that the increase in industrialization by creating enhanced environmental and technological awareness and people's access to sustainable energy technologies enhances SEC. The results revealed that during an inflationary period, there is a higher financial position for the country and its inhabitants. The increase in investment capacity enhances SEC. Likewise, the increase in population growth increases energy needs and human capital. So, it assists in implementing SEC. The study also finds that the increase in employment rate enhances the labor and the capacity of individuals to apply sustainable energy technologies. The study also concluded that the increase in eco-innovation encourages sustainable energy because it is an essential part of eco-friendly changes. Contrary to this, the study revealed that political instability negatively influences SEC. The political instability creates barriers in the way to implementing the adoption of SEC.

Limitations and future directions

The study also has some limitations worth paying attention to. Authors, with their efforts, can remove these limitations. This study address limited factors like industrialization, inflation, population growth, employment rate, co-innovation, and political instability for analyzing SEC. It ignores the more significant factors like energy transition, sharing economy, energy efficiency, and energy security in this research. Future scholars must also examine these factors for SEC. The current study pays only to SEC and shows no attention to sustainable energy production. Future authors are recommended to examine both SEC and production. Moreover, the study's validity is limited to many countries only because this study is based on data from Vietnam alone. So, for better validity, authors must collect data from multiple economies.

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Data availability The data that support the findings of this study are attached.

Declarations

Ethical approval The authors declare that they have no known competing financial interests or personal relationships that seem to affect the work reported in this article.

Consent to participate It can be declared that there are no human participants, human data, or human tissues.

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