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The influence of economic factors on the sustainable energy consumption: evidence from China

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ABSTRACT

Recently, sustainable energy consumption has been a significant factor in reducing environmental degradation due to the high economic growth, and this phenomenon demands more attention of scholars and policymakers. Thus, the current literature examines the impact of economic factors such as economic growth, foreign direct investment (FDI), inflation, and population growth on sustainable energy consumption (SEC), particularly in renewable energy consumption (REC) in China. This study used secondary data collection methods extracted from world development indicators (WDI), incorporating stationary tests like Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) to check the unit root of the constructs. The time-series data involved are from 1981 to 2019. The autoregressive distributed lag (ARDL) model was utilized to examine the association among the variables. The results indicated that economic growth, FDI, inflation, and population growth were positively associated with SEC in China. This study provides the guidelines to the policymakers to develop policies related to the SEC.

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1. Introduction

The economic growth of the countries has a positive correlation with rational thinking, better proposals, and well-developed strategies (Rahman & Velayutham, 2020; Zhao et al., 2021). China is the new leader of the world economy, proven with dedication and hard work (Elavarasan, 2020; Xueying et al., 2021). The nation abundantly produces industrial products, and it is adopting new and innovative technological

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options to cope with environmental degradation, habitat destruction, and carbon emission problems. China has the highest population growth rate, but things are becoming easy for them thanks to their planning and improvisation of resource utilization capacity. The economic growth of the Chinese nation is also tremendous. Asian economies are investing in the new resources of biofuel production. China has recently launched a new program to refine the agricultural waste and algal biomass for carbon dioxide (CO_2) fixation and bioremediation. Such initiatives are imperative for the economic growth and sustainability of all the world's economies. Developing countries like Bangladesh, Indonesia, Pakistan, India, and all the other Asian countries are also seeking new options of energy sources in place of fossil fuels. These options are easy to produce and environmentally friendly. The eco-friendly energy generation and resource utilization approaches increase the development and prosperity of the economy. The Chinese nation always supports such initiatives, and their government has close relationships with the world's economic leaders to have a strong back in all the situations (Kim et al., 2021; Othman et al., 2020 Tiwari & Marella, 2020; Xiang et al., 2021). Plastic recycling and usage of renewable energy sources in all industrial production processes is an important goal of the Sustainable Development Goals of the United Nations (Arjanggi & Kansedo, 2020; Moslehpour et al., 2022a; Tan et al., 2021). The increasing plastic pollution is detrimental to oceanic living beings. When living creatures engulf plastic waste, their life cycles are adversely affected, rendering them unfit for human consumption (Bahri et al., 2021; Moslehpour et al., 2022b; Sadiq et al., 2021c). So, for the well-being of the environment, population, and economies, new and innovative energy generation processes are essential (Arjanggi & Kansedo, 2020; Sadiq et al., 2021a).

In China, the biggest sources of energy production are coal and hydropower, with little focus on renewable energy production. It needs a high energy level as it is a high developing country with high economic growth. The non-renewable energy source produces high carbon emissions and affects the environment. Hence, focusing on the generation and consumption of renewable energy in the country is inevitable to produce high economic growth. The current study examines the role of economic factors on renewable energy consumption (REC) in the Chinese context and highlights the role of renewable energy in economic growth and a healthy environment. In addition, China has to purchase or share the abundant raw materials for biofuel generation from other economies, and they are now searching for new and innovative setups for the generation of renewable energy generation sources in a very economical way. These renewable energy resources can serve as alternatives to expensive and harmful fossil fuels as these fuel-based industrial processes emit CO_2 and other air pollutants. Microbial by-products and waste are also hazardous to the well-being of the environment and its inhabitants. So, China must utilize new and innovative resources to achieve excellence in its economic zone (Moslehpour et al., 2021; Nong et al., 2020; Sadiq et al., 2021b). Other important options for sustainable energy production are plant and animal waste to lower the fossil fuel reservoirs burden (Ioannidou et al., 2020). Figure 1 shows the different ways of energy generation in China.

The biggest source of energy generation is coal, which produces non-renewable energy and affects the environment. It calls for the focus on renewable energy. In

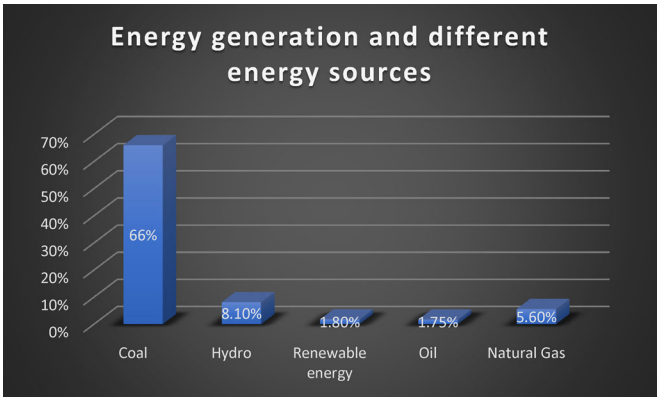

Figure 1. Energy generation resources in China.
Source: WDI.

addition, high economic growth demands high energy consumption, and this energy should be renewable; otherwise, it will affect the environment. Thus, the core objective of the study is to examine the economic factors on the consumption of REC that does not affect the environment. This study has considered four economic factors, i.e., economic growth, FDI, inflation, and population growth, to predict the REC, one of the first attempts, especially in the Chinese context. In addition, the current study has contributed to the gap in knowledge by providing the literature on economic growth and REC in the context of other countries. The present article also add contribution to the existing body of literature the association between FDI and REC, inflation and REC and population growth and REC. Moreover, this study provides policymakers guidelines regarding policies related to sustainable energy consumption (SEC).

The current study has examined the impact of economic growth on the REC based on the notion that economic growth is a changing phenomenon and needs further investigation. This was suggested by Eren et al. (2019), who investigated the economic growth role of REC in the Indian context. In addition, Caglar (2020) examined the FDI impact on the REC in nine countries and recommended that the other economic factors be examined along with the FDI to predict the REC and respond to this gap. This study added gross domestic product (GDP), inflation, population growth, and FDI to predict the REC. Moreover, Talha et al. (2021) investigated the impact of economic growth and inflation on REC in the Malaysia context and suggested that future articles should add more economic factors to predict REC and to respond this suggestion; the current article examines the FDI and population growth along with inflation and economic growth to predict REC.

The present study is divided into several phases. The first phase is the introduction, followed by evidence regarding economic factors and consumption of energy in the light of preceding studies. The third section of the study highlights the methodology applied for data collection regarding economic factors and energy consumption. The following section shed some light on the outcomes of the study and make comparison with the findings of past literature. This study also concludes the whole article with the proposed recommended solutions.

2. Literature review

Economic disequilibrium is a highlighted issue in the current world that enumerates the externalities and mobility of resources. The sustained growth of economies not only explores various opportunities but also encompasses energy consumption issues. Liu et al. (2021a) and Pegkas (2020) investigated the impact and relationship between economic growth, non-renewable energy, and renewable energy with the consolidated effect of SEC in Greece. The short-run and long-run effects were examined over the elected factors using regression analysis and other statistical techniques. The results indicated that the significant stimulation of economic growth protects the expansion and sustainability of energy consumption with the substitute of conventional energy. Kais and Ben Mbarek (2017) examined the relationship between economic growth, sustainable energy consumption, and carbon emissions in three countries of North Africa. Different corresponding factors of elected factors were considered for interpreting the relationship. The co-integration approach and panel unit root tests with other techniques were applied to determine the linkage among the factors. The study revealed the positive indication that developing and sustainable economic growth influences sustainable energy consumption. Khoshnevis Yazdi and Ghorchi Beygi (2018) and Liu et al. (2021b) asserted the dynamic impact and relationship between financial development, renewable and sustainable energy consumption, and carbon emission in selected countries of Africa. The impacts and relationships were explored by considering urbanization growth, trade openness, economic growth, energy consumption, renewable energy, carbon emission, and financial development. Granger causality and pooled mean group approach stated considerable effects of financial development and economic growth on sustainable energy consumption.

The improvement in economic growth increases the well-being of human beings that enhances the share of energy purchased by the people. Increment in economic growth also doubles energy production and helps sustain economic growth. Shahbaz et al. (2018) assessed the strength of the causal relationship between sustainable energy consumption and globalization in the economies of developed countries. For this purpose, numerous factors were elected like sustainable energy consumption, globalization, and economic growth with corresponding elements. Correlation, unit root tests, co-integration techniques, and other tests were applied to the selected factors. The study shows that causality and efficiency influence economic tools over efficient and sustainable energy consumption. Li et al. (2021) and Ab. Wahab (2017) investigated the relationship between sustainable energy consumption, sustainable working behaviors, and religious work values among Muslim employees. This relationship aims to assert the economic values and their contribution toward sustainable energy consumption. For this reason, numerous structural equation modeling techniques have been used with other models. The study indicated that the effectiveness and strengthening of economic growth support sustainability in energy consumption. Nguyen et al. (2019) discussed the demographics of emerging economic markets and sustainable technology and energy consumption with the efficient emergence of energy. Energy efficiency is the main element supported by the significance of economic growth. Statistical and econometric techniques were used to assert the relationship between economic growth and sustainable energy consumption. The study

revealed the effectiveness of economic growth toward sustainable energy. Hence, the following hypotheses were developed:

H1: Economic growth and renewable energy consumption are positively associated with eachother.

FDI has been considered the most attractive issue for all energy sectors globally. Moreover, the rise in the energy sector has been nominated as the most attractive by foreign investment that enlarged the production and consumption of energy. Huang et al. (2021c) and Wye (2018) explored the relationship between trade and FDI and its incorporation into the employment-energy in China. Energy consumption and energy growth have gained rapid increase due to the continuous development of FDI. The nexus between the relationship has been significantly elaborated by the induction of various statistical and econometric techniques. The study revealed the possible and positive impact of FDI on sustainable energy consumption. Wall et al. (2019) assessed the instrumental policies in the sustainability of REC where FDI is attracted. The mitigating effects of FDI pose multiple policies that help production, development, and energy consumption. The impacts have been ascertained by applying econometric and statistical techniques to attract investment. The results indicated a positive and significant influence of FDI on the sustainability of energy consumption. Meanwhile, A. Khan et al. (2020) investigated the repercussions of environmental decays, health expenditures, renewable energy, and FDI in BRI countries. The initiatives and benefits of sustainable energy consumption have robust interference of different investment elements. The generalized method of moments and least square methods has been applied in establishing the relationship among the elected factors. The study posed a significant relationship between FDI and SEC.

The funds around the world are most significant toward the betterment of energy and other sectors. FDI through various incentive schemes to the developing countries helped in the sustainability of energy consumption. Huang et al. (2021b) and Manyuchi (2017) examined the transformation of environmental technologies in the energy sector and the implications of FDI in Uganda. The increment in FDI increases not only the sustainability of energy consumption but also other factors. At the same time, they are exploring the effects of FDI on the energy sector, utilizing secondary and primary approaches. Results demonstrated significant impacts of FDI on sustainable energy consumption. Kuhe and Bisu (2020) enumerated the influence and relationship between energy consumption behaviors and the economy's situational factors. According to the international investment, this is considered a step toward the effectiveness and development of the energy policy. In determining the relationship and influence, structural and econometric techniques have been applied. Findings stated that development in situational factors like FDI promotes sustainability in household energy consumption. Maleviti et al. (2012) discussed the attitudes and consumption of energy according to sustainability in the development of various motives. The aim was to demonstrate the consumption and behaviors developed according to the interaction of FDI. Different statistical and strategic plans are implemented to assert the response of international investment toward energy consumption. The finding indicated the reduction of energy consumption due to the lack of FDI. Thus, the study established the hypothesis as follows:

H2: FDI and renewable energy consumption are positively associated with eachother.

Inflation is the main economic factor considered a risk to the major sectors of energy and financial sectors. However, the inflation in energy also attracts foreign countries to divert their purchase intentions. Koç Yurtkur and Bahtiyar (2017) explored the relationship between trade openness, inflation, economic growth, and energy consumption among the five fragile countries. The macroeconomic factors consistently exert desirable effects on the energy components. The elements linked with inflation are examined similarly to the components of financial aspects by applying various statistical approaches. Results indicated a significant rise in inflation endorses an emerging impact on sustainable energy consumption with energy dynamics. Aydin and Esen (2018) and Huang et al. (2021a) analyzed the levels of energy intensity where the effects on sustainable energy consumption prevail due to the transitional growth of economies. Economic growth could be retarded by insignificant energy consumption, and the economic levels include inflation elements. The insignificance is well narrated among the relationship between inflation and sustainable energy consumption after applying the threshold regression model. Results specified the positive impacts of inflation in energy, promoting sustainable energy consumption. Iqbal et al. (2021), who investigated the dynamics of inflation and structural determinants of sustainable energy consumption in Pakistan, reported an enormous fluctuation in sustainable energy that is interfered with by the volatile role of inflation. The critics of inflation and sustainable energy are elaborated by the unit root and bound tests with other statistical techniques. The study reveals that energy inflation is against the energy demand and disrupts sustainable energy consumption.

Infinite demand and energy supply are also the main inflation issue that could disrupt sustainable energy consumption. In contrast, the effective sustainability of energy prices due to energy inflation raises the sustainable efforts for energy consumption. Ehsanullah et al. (2021) and Ngarava (2021) interrogated the long-term link between inflation, energy, and food in South Africa. The price volatilities of inflation tendencies place direct and indirect effects on the energy components. For this purpose, different factors of inflation and relatively energy-related factors are explored using the vector autoregressive model. The study builds the positive impact of inflation in energy and energy-related components on the sustainable consumption of energy. Meanwhile, Haider and Adil (2019) assessed industrial energy consumption with trade openness, financial development, and inflation for the development and sustainable perspective. Different macroeconomic factors have also been considered to check the frequency of sustainability in energy consumption. An autoregressive distributed lag bounds testing approach and vector error correction model have been integrated to assert the relationship. The study confirms the ability of inflation and its dominant impact on sustainable energy consumption. Banday and Aneja (2020) viewed the link between carbon emission, economic growth, energy consumption, and other macroeconomic factors in the BRIC (Brazil, Russia, India, and China). While indicating the dominance of inflation and other economic factors, the GDP and economic growth are taken as essential factors. Panel causality tests are applied with other statistical techniques to check the dependency and independency of inflation. The study refreshed the energy inflation and other macroeconomic factors helping in sustainable energy consumption.

Countries having high income lead their population growth toward the demand for global energy for its sustainable efforts. The transmission of population growth effectively with the aim of development goals contributes a significant proportion toward sustainable energy consumption. Rahman (2017) enumerated the adverse relationship between environmental quality, population density, energy use, and economic growth in popular countries of Asia. The relationship has been examined using various components linked to population growth and sustainable energy consumption. Dynamic and modified ordinary least square methods have been used to examine the link among them. Results indicate that the effective use of population density and population growth promotes the effective use of sustainable energy consumption. Ganivet (2020) investigated the consumption of energy and growth in the human population for addressing sustainability in the ecological future. It is dependent on the population growth to connect with the environmental and climate change that may fluctuate due to the instability in energy consumption. The study shows the attention of population growth influencing sustainable energy consumption. Heinrich et al. (2020) and Namahoro et al. (2021) examined the impact and relationship between carbon emissions, population and economic growth, and renewable energy in East Africa. The positive growth in population by providing every means and development for humans could effectively promote energy consumption. For this purpose, causality tests and nonlinear autoregressive distributed lagged methods have been used. Studies revealed that effective and positive growth of the population helps sustain energy consumption. Hence, the study developed the following hypothesis:

H3: Inflation and renewable energy consumption are positively associated with eachother.

The growth of population is counted as a crucial factor that emerges worldwide to enable sustainable energy and environmental changes. Urbanization is considered a powerful driver that inserts considerable efforts for sustainable energy consumption. Chen et al. (2019) assessed the optimization and multi-objective of population constraint and economic emission by incorporating energy resources effects. Energy consumption has been improved with the advanced technology demonstrated by the feasible growth in population. While asserting the improvement, the statistical techniques have asserted a vital role among the elected factors. Results indicated volatile growth in population, and its development through different means could sustain the energy consumption. Zaid et al. (2017) explored the conventional green offices emerging with the population growth inserting effect on the operational energy consumption in Malaysia. Changing climate and global warming are humanity's biggest issues due to the largest energy consumption. The contribution of population growth is effectively asserted by applying strategic, structural, and statistical techniques. Results highlighted the effective development of population growth could promote sustainability in energy consumption. Chien et al. (2022) and Waris and Hameed (2021) investigated the intentions of consumers that have been enhanced due to population growth and placing an effect on the efficiency of purchasing energy. Consumers' intentions are well denoted by the involvement of population growth that enlarges the instability and sustainability of energy consumption. Sampling techniques of statistical tools and econometric impacts emphasized the relationship between population growth and sustainable energy consumption. Finding revealed the proper

knowledge, information, and upbringing over the population growth establishes the sustainable energy consumption. Thus, the study established the following hypothesis:

H4: Population growth and renewable energy consumption are positively associated with each other.

3. Research methodology

The study scrutinizes the effect of economic growth, FDI, inflation, and population growth on the SEC in China. Since the high energy consumption and non-renewable energy source due to the high economic growth needs top the list that affects the environment in China, the current study examines the impact of an economic factor on REC that reduces environmental degradation with high economic growth. The current article made the use of secondary data and extracted the data from, WDI ranging from 1981 to 2019. The equation of study is as follows:

$$SEC_t = \alpha_0 + \beta_1 EG_t + \beta_2 FDI_t + \beta_3 INF_t + \beta_4 PG_t + e_t \quad (1)$$

Where;
SEC = Sustainable Energy Consumption
t = Time
EG = Economic Growth
FDI = Foreign Direct Investment
INF = Inflation
PG = Population Growth

The current study has used the SEC as the dependent variable and measured REC in terms of total energy consumption %. In addition, four economic factors were used as the predictors, i.e., economic growth and measured as the GDP growth (annual percentage), FDI measured as the net inflows (% of GDP), inflation was measured through the consumer prices (annual percentage), and population growth was measured through the growth of population (annual percentage). These measurements are shown in Table 1.

Firstly, the present article depicts the descriptive statistics highlighting the total observation used, standard deviation, and maximum and minimum values of all the variables. In addition, year-wise descriptive statistics are also shown in the study. Moreover, the correlation matrix is also highlighted in the results section, which explores the nexus among the constructs. The present article has also examined multicollinearity using the variance inflation factor (VIF). The current article also examines the unit root using the ADF and PP tests because selecting the appropriate model is based on the stationarity

Table 1. Variables with Measurements.

S#	Variables	Measurement	Sources
01	Sustainable Energy Consumption	Renewable energy consumption (% of total energy consumption)	World Development Indicators
02	Economic Growth	GDP growth (annual %)	World Development Indicators
03	Foreign Direct Investment	Net inflows (% of GDP)	World Development Indicators
04	Inflation	Consumer prices (annual %)	World Development Indicators
05	Population Growth	Population growth (annual %)	World Development Indicators

Source: Authors estimation.

of the variables. If all variables are stationarity or have no unit root at level, then ordinary least square is the appropriate model for the study, but if all the variables are stationary at the first difference, then the error correlation model (ECM) is appropriate. In addition, the ARDL model can be executed when all the variables are stationary at the level, or all the variables are stationary at the first difference, or some are stationary at the level, and some are stationary at the first difference. The ADF equation is as follows:

$$d(Y_t) = \alpha_0 + \beta t + \mathrm{Y}Y_{t-1} + d(Y_t(-1)) + \varepsilon_t \tag{2}$$

The ADF test characteristic is that it checks the stationarity of each variable. Thus, the mathematical notion for each construct are as follows:

Sustainable energy consumption

$$d(\mathrm{SEC}_t) = \alpha_0 + \beta t + \mathrm{YSEC}_{t-1} + d(\mathrm{SEC}_t(-1)) + \varepsilon_t \tag{3}$$

Economic growth

$$d(EG_t) = \alpha_0 + \beta t + \mathrm{Y}EG_{t-1} + d(EG_t(-1)) + \varepsilon_t \tag{4}$$

Foreign direct investment

$$d(FDI_t) = \alpha_0 + \beta t + \mathrm{Y}FDI_{t-1} + d(FDI_t(-1)) + \varepsilon_t \tag{5}$$

Inflation

$$d(INF_t) = \alpha_0 + \beta t + \mathrm{Y}INF_{t-1} + d(INF_t(-1)) + \varepsilon_t \tag{6}$$

Population growth

$$d(PG_t) = \alpha_0 + \beta t + \mathrm{Y}PG_{t-1} + d(PG_t(-1)) + \varepsilon_t \tag{7}$$

In addition, the authors have used the ARDL model because it is an appropriate model when all the variables are stationary at the level, or all the variables are stationary at the first difference, or some variables are stationary at the level, and some variables are stationary at the first difference. The ARDL model is also suitable for small samples (Chien et al., 2021a; Flores & Chang, 2020; Sharif et al., 2020), as the current article has 39 observations. Moreover, the ARDL approach generates both short run and long-run results. The ARDL model mathematical notion is as follows:

$$\begin{aligned}\Delta\mathrm{SEC}_t = \alpha_0 + \sum \delta_1 \Delta\mathrm{SEC}_{t-1} + \sum \delta_2 \Delta EG_{t-1} + \sum \delta_3 \Delta FDI_{t-1} + \sum \delta_4 \Delta INF_{t-1} \\ + \sum \delta_5 \Delta PG_{t-1} + \varphi_1 \sec_{t-1} + \varphi_2 EG_{t-1} + \varphi_3 FDI_{t-1} + \varphi_4 INF_{t-1} + \varphi_5 PG_{t-1} + \varepsilon_1\end{aligned} \tag{8}$$

In equation 8, δ_1, δ_2, δ_3, δ_4, and δ_5 show the short-term coefficients; contrary to, φ_1, φ_2, φ_3, φ_4, φ_5, and ε_1 represent the long-term coefficients and error term. In addition, the ECM equation is given below for short-run relationships.

$$\Delta SEC_t = \alpha_0 + \sum \delta_1 \Delta SEC_{t-1} + \sum \varphi_2 \Delta EG_{t-1} + \sum \omega_3 \Delta FDI_{t-1} + \sum \theta_4 \Delta INF_{t-1} + \sum \Upsilon_5 \Delta PG_{t-1} + \delta ECM_t + \upsilon_t \quad (9)$$

Finally, the authors also used the granger causality and Toda-Yamamoto causality tests to examine the unidirectional, bidirectional, and no association among the variables. The granger causality equation is mentioned below:

$$Y_t = \beta_0 + \sum\nolimits_{j=1} \beta_{1j} Y_{t-1} + \sum\nolimits_{h=1} \beta_{2h} Y_{t-p} + \varepsilon_t \quad (10)$$

$$X_t = \Phi_0 + \sum\nolimits_{s=1} \Phi_{1s} Y_{t-s} + \sum\nolimits_{t=1} \Phi_{2t} X_{t-m} + \varepsilon_t \quad (11)$$

4. Study results

Firstly, the current study has shown descriptive statistics highlighting the total observation used, standard deviation maximum and minimum values of all the variables. The numbers indicated that a total of 39 observations were used. In addition, the SEC mean value is 24.201%, while EG average value is 9.482%. Moreover, the findings also show that the mean value of FDI is 2.718%, INF avg. value is 5.259%, and PG's avg. value is 0.907%. The descriptive statistics are shown in Table 2.

Moreover, the present study also stimulates the year-wise descriptive statistics of chosen variables. The figures stimulated that the minimum value of SEC is 11.338% in 2011, while the maximum value of SEC is 34.122% in 1989. Additionally, the EG minimum values was 3.920% in 1990, while maximum (15.192%) in 1984. The figures also indicate that the minimum value of FDI is 0.135% in 1981, while the maximum value of FDI is 6.187% in 1993. In addition, the minimum value of INF is −1.401% in 1999, while the maximum value of INF is 18.812% in 1988. The minimum value of PG is 0.357% in 2019, while the maximum value of PG is 1.610% in 1988. The descriptive statistics by year are shown in Table 3.

Moreover, the correlation matrix is also highlighted in the results section, which examine the relationship among variables. The results indicated that EG, FDI, INF, and PG have a positive association with SEC. In addition, a 1% change in EG will change the SEC by 18.9%, while a one-unit increase in FDI will increase the SEC by 0.211 units and vice versa. Moreover, a 1% change in INF will change the SEC by

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
SEC	39	24.201	9.219	11.338	34.122
EG	39	9.482	2.759	3.920	15.192
FDI	39	2.718	1.703	0.135	6.187
INF	39	5.259	5.842	−1.401	24.257
PG	39	0.907	0.410	0.357	1.610

Source: Authors estimation.

Table 3. Descriptive statistics (Years).

	SEC	EG	FDI	INF	PG
1981	33.018	5.113	0.135	6.019	1.281
1982	33.110	9.017	0.210	6.187	1.473
1983	33.298	10.77	0.276	6.355	1.445
1984	33.422	15.192	0.484	6.523	1.312
1985	33.562	13.431	0.536	6.691	1.362
1986	33.702	8.950	0.623	6.859	1.487
1987	33.842	11.657	0.848	7.234	1.604
1988	33.982	11.223	1.023	18.812	1.610
1989	34.122	4.206	0.976	18.246	1.533
1990	34.084	3.920	0.966	3.052	1.467
1991	33.258	9.263	1.139	3.557	1.364
1992	32.931	14.225	2.613	6.354	1.226
1993	31.678	13.884	6.187	14.610	1.150
1994	31.249	13.037	5.987	24.257	1.130
1995	29.472	10.954	4.880	16.791	1.087
1996	30.537	9.923	4.652	8.313	1.048
1997	30.183	9.237	4.725	2.786	1.023
1998	29.740	7.846	4.436	−0.773	0.960
1999	30.506	7.662	3.749	−1.401	0.866
2000	29.603	8.490	3.475	0.348	0.788
2001	28.335	8.336	3.513	0.719	0.726
2002	26.978	9.134	3.609	−0.732	0.670
2003	23.841	10.038	3.487	1.128	0.623
2004	20.161	10.114	3.484	3.825	0.594
2005	17.441	11.395	4.554	1.776	0.588
2006	16.385	12.721	4.509	1.649	0.558
2007	14.884	14.231	4.401	4.817	0.522
2008	14.138	9.651	3.734	5.925	0.512
2009	13.432	9.399	2.569	−0.728	0.497
2010	12.261	10.636	4.004	3.175	0.483
2011	11.338	9.551	3.709	5.554	0.479
2012	11.537	7.864	2.827	2.620	0.487
2013	11.522	7.766	3.040	2.621	0.494
2014	12.061	7.426	2.559	1.922	0.506
2015	12.245	7.041	2.192	1.437	0.508
2016	12.590	6.849	1.556	2.000	0.541
2017	12.864	6.947	1.349	1.593	0.559
2018	13.124	6.750	1.694	2.075	0.456
2019	13.384	5.950	1.311	2.899	0.357

Source: Authors estimation.

Table 4. Correlation matrix.

Variables	SEC	EG	FDI	INF	PG
SEC	1.000				
EG	0.189	1.000			
FDI	0.211	0.335	1.000		
INF	0.433	0.299	0.078	1.000	
PG	0.911	0.154	−0.432	0.546	1.000

Source: Authors estimation.

43.3%, while a one-unit increase in PG will increase the SEC by 0.911 units and vice versa. These relationships are shown in Table 4.

The present article has also examined multicollinearity using VIF. The results presented in Table 5 demonstrate that the values are < 5, indicating multicollinearity is not the problem in the model.

The current article also examines the unit root using the ADF and PP tests because selecting the appropriate model is based on the variable stationarity. The results indicated that EG and INF are stationary at a level, while SEC, FDI, and PG are

Table 5. VIF.

	VIF	1/VIF
EG	2.875	0.348
FDI	2.882	0.347
INF	1.229	0.831
PG	2.102	0.476
Mean VIF	2.272	.

Source: Authors estimation.

Table 6. Unit Root Test.

	ADF Test		PP Test		
	t-stats	Sig-values	t-stats	Sig.values	Decisions
SEC	−5.500	0.000	−4.091	0.002	I(1)
EG	−4.713	0.001	−2.902	0.035	I(0)
FDI	−3.476	0.011	−5.017	0.000	I(1)
INF	−5.548	0.000	−2.091	0.048	I(0)
PG	−4.867	0.000	−6.990	0.000	I(1)

Source: Authors estimation.

Table 7. ARDL Bound Test.

				Bound test critical values	
Model	F-stats	Lag	Sig level	I(0)	I(1)
SEC/(EG,FDI,INF,PG)	6.68	4	1%	6.91	6.97
			5%	5.17	5.49
			10%	4.03	4.09

Source: Authors estimation.

Table 8. Short Run Coefficients.

Constructs	Coeff	Std. Error	t-Stats	Sig.value
D(EG)	0.620860	0.140242	4.427062	0.0110
D(FDI)	0.776452	0.131029	5.925803	0.0022
D(INF)	1.190552	0.158634	7.505024	0.0000
D(PG)	1.421462	0.242542	5.860684	0.0025
CointEq(-1)*	−1.384823	0.153171	−9.041026	0.0000
R-squared	0.466651	Mean dependent var		−0.060852
Adjusted R-squared	0.435255	S.D. dependent var		2.525322

Source: Authors estimation.

stationary at the first difference. The results indicate that the ARDL model is appropriate. The ADF and PP tests are shown in Table 6.

In addition, co-integration among the variables is imperative for ARDL model, and it is checked using the 'ARDL bound test'. The results indicate the higher F-stats which are larger in comparison with critical values. The results indicated that co-integration exists, and authors can use the ARDL model. The ARDL bound test results are shown in Table 7.

The results of the ARDL model indicate that economic growth, FDI, inflation, and population growth is positively correlated with SEC in the short run. In addition, a 1% change in EG will change the SEC by 62.08%, while a one-unit increase in FDI will increase the SEC by 0.776 units and vice versa. Moreover, a 1% change in INF will change the SEC by 119.06%, while a one-unit increase in PG will increase the SEC by 1.421 units and vice versa. In addition, the 46.66% variations in the SEC are due to all the predictors used. These relationships are shown in Table 8.

Table 9. Long term coefficients.

Constructs	Coeff	Std. Error	t-Stats	Sig. Vlaue
EG	1.288623	0.419853	3.069224	0.0012
FDI	3.892114	1.144177	3.401671	0.0009
INF	1.285651	0.261687	4.912934	0.0000
PG	2.462782	0.823915	2.989121	0.0315
C	0.955174	0.278095	3.434704	0.0002
R Square	0.692021			
CUSUM	S			
CUSUMQ	S			

Source: Authors estimation.

The results of ARDL also indicated that economic growth, FDI, inflation, and population growth have a positive association with SEC in the long run. In addition, a 1% change in EG will change the SEC by 128.86%, while a one-unit increase in FDI will increase the SEC by 3.892 units and vice versa. Moreover, a 1% change in INF will change the SEC by 128.56%, while a one-unit increase in PG will increase the SEC by 2.463 units and vice versa. The R square value indicated that a 69.20% in SEC is due to all predictors used in the study. In addition, the CUSUM and CUSUM square indicate that the model is stable. These relationships are shown in Table 9.

The results in figure 2 also show the Granger causality and the results expose the unidirectional nexus among EG and SEC and FDI and SEC. Moreover, the findings also depicts the bidirectional nexus among INF and SEC while no relationships among PG and SEC. These relationships are shown in Table 10.

The Toda-Yamamoto causality test results indicate the unidirectional nexus among EG and SEC and FDI and SEC. Moreover, the results stimulate the bidirectional nexus among INF and SEC while no relationships among PG and SEC. These relationships are shown in Table 11.

5. Discussions

The study results indicated that economic growth positively correlates with sustainable energy consumption (SEC). These results are supported by Ozcan and Ozturk (2019), who demonstrated that when a country keeps on making high economic growth, progress is observed in all economic areas, including agriculture, forestry, tourism, mining, and natural resources refineries like coal and oil refineries. The resultant consistent increase in the productivity of agriculture, forestry, tourism, mining, and natural resources refineries enhances energy reserves for sustainable consumption in domestic and economic activities. The findings are also backed by Shao et al. (2019), who analyzed the impacts of economic growth on SEC within the country. Such initiatives must be taken to achieve SEC as they could reduce energy use for performing the same tasks in the present. Moreover, initiatives like energy-efficient technologies and techniques are likely to be taken only if there are large financial resources, which is possible when the country is making rapid economic progress. These results are in line with the study by M. K. Khan et al. (2020), who reported that economic growth is not an individual effort but the result of collective efforts on the part of all economic sectors like agriculture, forestry, tourism, mining, natural resources refineries, manufacturing and financial sectors as they all contribute to the

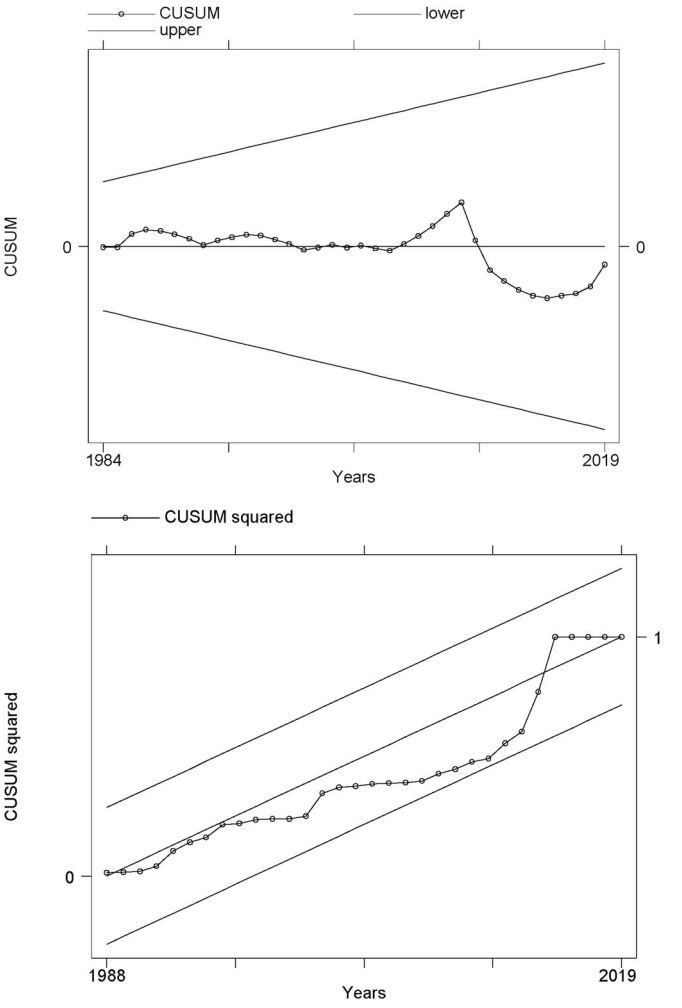

Figure 2. CUSUM and CUSUM Square.
Source: Authors estimation.

Table 10. Granger Causality Test.

Null Hypothesis	F-Statistic	Prob.	Decision
EG does not Granger Cause SEC	6.04058	0.0000	Unidirectional
SEC does not Granger Cause EG	0.50206	0.5860	
FDI does not Granger Cause SEC	3.01466	0.0199	Unidirectional
SEC does not Granger Cause FDI	0.12800	0.4057	
INF does not Granger Cause SEC	3.55981	0.0124	
SEC does not Granger Cause INF	4.08623	0.0044	Bidirectional
PG does not Granger Cause SEC	0.5521	0.6247	
SEC does not Granger Cause PG	1.1251	0.4231	No

Source: Authors estimation.

country's GDP. The consistency in the productivity of agriculture, forestry, and mining refills the sources for energy production and makes energy consumption sustainable. These results are congruent to the study by Brini et al. (2017) and Chien et al. (2021b), who stated that when the country makes economic progress, and its population is prosperous, it can afford renewable energy sources and energy efficiency

Table 11. Toda-Yamamoto Causality Test.

Dependent Variables	SEC	EG	FDI	INF	PG
SEC	***	2.763(0.024)**	0.984 (0.226)	3.652 (0.025)**	0.727 (0.939)
EG	0.872 (0.563)	***	2.981 (0.012)**	4.873 (0.02)**	1.531 (0.123)
FDI	3.827(0.022)**	2.877(0.032)**	***	0.902 (0.222)	2.988 (0.043)**
INF	4.829 (0.011)**	0.848 (0.298)	3.928 (0.011)**	***	2.102 (0.054)*
PG	1.727 (0.439)	0.822 (0.109)	5.983 (0.000)***	3.652 (0.023)**	***

Source: Authors estimation.

through the procurement of energy-efficient materials, resources, and technologies. Thus, they could save energy sources for consistent use in business activities.

The findings also depict that FDI associated with SEC in positive manner. The findings are also backed by Zafar et al. (2019), who stated that FDI raises financial resources within the country. These resources can be used to develop consistency in business operations by producing and preserving energy resources for present and future uses. Hence, FDI enhances sustainability in the use of energy sources. The results are also in accordance with Chien et al. (2021c) and Shahbaz et al. (2019), who showed that when the individuals or organizations that dealt in energy production like mining firms (dealing in the extraction of fossil fuels), agriculture and agriculture-based firms, forestry, and enterprises that produce energy from natural sources, have large finances in the form of FDI, they develop sustainability in the energy production and assures the sustainable energy use in all the other economic sectors. These results are congruent to Behera and Dash (2017), who checked the relationship between FDI and sustainability in energy consumption. This study posits that when the government encourages FDI by allowing the foreign individuals, enterprises, or government authoritative personnel to visit the country and make an investment in the extraction of fossil fuels like oil, coal, gas, petroleum, and ore, and production of renewable energy like biomass, biofuel, and solar power, there is sustainability in the energy consumption within the country. These results also support Salahuddin et al. (2018) and Dlalisa and Govender (2020), whereby as the FDI raises funds within the country, the organization can not only meet the present energy needs but also assures the availability of energy sources for future use by applying the energy-efficient machines, resources, and processes of consuming energy.

The study results also showed that inflation within the country is positively associated with SEC. These findings are supported by Hidayatno et al. (2019), who analyzed the impact of the inflation rate on the SEC. This study reveals that when inflation is at its peak within the country, the productivity within all the economic sectors is also high. The manufacturing, service, and transportation sectors need more energy sources to expand their businesses and run their activities smoothly. Thus, the consumption of energy sources is sustainable during inflation. These results are also supported by Koloba (2020) and Rafindadi and Mika'Ilu (2019), who stated that during the inflation period, the economic activities (production, transportation, and services rendering) are at a high rate, and there is a demand for large energy sources. The business organizations by themselves arrange for energy production for sustainable use in performing economic activities to keep pace with the market demands. These results agree with the previous study by Shah et al. (2020) and Kikulwe and Asindu (2020), who posited that when the country makes high economic growth, business

organizations can apply energy-efficient technologies, resources, and processes, and by themselves, the production clean and renewable energy which can be renewed, reused, and leaves no wastes. In this way, energy sources can be increased, and energy can be sustained.

The study results indicated that population growth has a positive association with SEC. These results support the study by Zaman and Abd-el Moemen (2017), who highlighted that in a country with a high population growth rate, the demand for energy sources to be used both for household and commercial activities is also high. The high demand triggers the prices of energy sources and encourages energy production on a large scale. The energy produced in excessive amounts can be saved for future use. These results are also supported by Dong et al. (2018), who showed that the increase in the population growth rate provides fresh and skilled human capital to the country. The skilled human capital works for better outcomes with some innovative changes; hence, they find ways to produce maximum energy from minimum resources and save energy by performing the same tasks with minimum energy consumption and waste. Thus, sustainability in energy consumption is possible with increasing population growth. These results also agree with Rahman (2017), who stated that when, in a country, the population growth rate is high, the need for the energy resources increases, both at the domestic and commercial level, to undertake different household and economic activities, heating, cooling, lighting, transportation, and production activities. Considering the increasing demand for energy and limited availability of traditional energy sources like fossil fuels (oil, coal, natural gas, and ore), the government and the private organizations focus on the production of renewable energy so that sustainability can be created in the consumption of energy without any chance of delay.

6. Implications

The current study has a great theoretical significance as it contributes to the literature on economic sustainability. This study analyzes the role of economic factors in getting sustainable energy consumption within the economy. The study analyzes the influences of four significant economic component like 'economic growth, FDI, inflation rate, and population growth' on sustainability development in energy consumption in the economy. Although many authors have focused on the economic conditions or economic factors while analyzing the sustainability development in energy consumption, the conduct of this study is the first attempt to give a detailed description of the economic conditions or economic factors as the predictor of energy consumption. In the existing literature, scholars have explored the influences of the economic growth, FDI, inflation rate, and population growth on sustainability development in energy consumption in the economy, but a single study has discussed the influences of one of the following aspects: economic growth, FDI, inflation rate, and population growth on sustainability development in energy consumption. The previous study analyzed the FDI as the driver of sustainable energy consumption and demonstrated the need to explore the economic and population impact on sustainable energy consumption. The current study, which analyzes the influences of economic

growth, FDI, inflation rate, and population growth on sustainability development in energy consumption, is a significant contribution to the literature. The study is also significant for emerging economies like China as it guides economic development consistency with SEC. This study guides the economists and government on how they must develop policies to encourage sustainability in energy consumption and provides help to the policymakers in developing policies related to the SEC. The study suggests that sustainability in energy consumption can be developed with the increase in economic growth, FDI, inflation rate, and population growth.

7. Conclusion and limitations

The current article concludes that the Chinese economy is also focusing on the production and consumption of renewable energy, which is the reason for all the economic factors playing a positive role in the REC. Thus, the analysis indicates the positive correlation between economic growth, FDI, inflation rate, population growth, and sustainable development in energy consumption. These results indicated that when the country is making rapid economic growth, there is an upward trend in productivity, transportation, services, financing, and profitability which encourages the production of energy sources and develops sustainability in the energy consumption. The study results have indicated that as FDI raises financial resources within the country, firms not only cover current energy needs but also ensure the availability of energy sources for future usage by implementing energy-efficient technologies, resources, and consumption processes. The study results also revealed that the demand for energy sources in domestic and commercial operations is considerable in countries with a high population growth rate. High demand drives up the cost of energy sources and encourages large-scale energy production. The energy that is produced in excess can be conserved for future use. The study also concluded that when there is inflation in the country, like all the other sectors, the productivity in the enterprises that deal in energy also rises. This large-scale production of energy sources assures sustainability in energy consumption.

The current study has several limitations despite the theoretical and empirical implications. Upcoming authors are recommended to remove these limitations for conducting a more reliable study. First, the study throws light on only four economic factors: economic growth, FDI, inflation rate, and population growth, while analyzing the sustainability development in energy consumption in the economy. Other factors like green finance, renewable energy production, energy efficiency, etc., can influence sustainable energy consumption. But none of these factors has been analyzed in this study. Upcoming authors are recommended to expand the scope of the study by exploring these essential factors to determine sustainable energy consumption. Moreover, the current study results about the nexus between economic growth, FDI, inflation rate, population growth, and sustainable development in energy consumption were based on the analysis of the economy of China. China is a developing country having specific economic conditions, so the study may not be equally valid in other developing or developed economies. For a more valid study, the authors must analyze multiple economies in this regard.

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