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THE PERCEIVED RELATIONSHIP BETWEEN SUSTAINABLE ENERGY TECHNOLOGIES, ECO-INNOVATION, ECONOMIC GROWTH AND SOCIAL SUSTAINABILITY: EVIDENCE FROM CHINA

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Abstract. Social sustainability is a global necessity because of environmental and economic uncertainty. This issue needs the foremost solution, and for this purpose, researchers' and policymakers' emphasis is required. Thereby, the present paper investigates sustainable energy technologies such as solar and hydroelectric, eco-innovation and EG and their impact on social sustainability in China. The study also used industrialization and inflation as the control variables in the time span of 1981 to 2020. The present study also applied the Dynamic Auto-regressive Distributed Lags (DARDL) model to evaluate the association between the outlined variables. The results indicated that sustainable energy technologies such as solar and hydroelectric, eco-innovation, economic growth, industrialization and inflation are significantly associated with social sustainability in China. The present paper offers standard policies to regulators in making regulations related to maintaining social sustainability by using effective sustainable energy technologies and eco-innovation.

Keywords: sustainable energy technologies, social sustainability, eco-innovation, economic growth, industrialization, inflation.

JEL Classification: Q01, Q56, O35, O47.

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1. Introduction

Over the past few decades, the importance of social sustainability has been accelerating at a rapid pace. Prior to that, the world has more focused on economic development and sustainability but now different concerns like ecological concerns have forced the world to consider the social factors at the core level with the view to minimizing their adverse effect on the world. The countries are now equally rating social sustainability with the economic. The inculcation of sustainability in company processes appears to be a major issue of organizations (Yodchai et al., 2022; Waddell, 2021). It is argued that contemporary firms are needed to shift beyond green practices and must shape their thought processes and adapt and innovate business practices and procedures which are more sustainable in nature. Majority of the project in this regard emphasized on economic and environmental aspects of SD,

however, in this struggle they failed to focus social aspect. In recent times, besides environmental aspects, social sustainability has gained equal recognition, however, the negligence in this area, raised numerous concerns regarding its incorporation in to commercial operations (Gaines & Kasztelnik, 2021; Wang & Shaw, 2018). Few businesses opt existing indicators to embellish the sustainability value. Whereas others divulge themselves to build their very own set of indicators to execute the idea. Literature also states that principle social elements such as "justice and equality, poverty, health, education, delinquencies, demography, culture, and employee involvement" within a business must be platformed together along with economic and environmental sustainability (Dat et al., 2022; Zhang et al., 2018). In order to achieve the ultimate sustainable outcomes, organizations are concentrating their efforts in sustainable business strategies on the basis of social indicators.

In global market, there is a growing and consistent competition has been observed in recent years. As can be seen, countries are competing against each other in order to gain sustainable growth, however, these countries also face pressure to achieve suitability by addressing climate related issue and showing care for well-being. It is quite imperative to do so as it is connected to sustainable development goals which state that countries are obliged to make progress in all sustainability areas (Cera et al., 2022; Yi et al., 2021b). Thus, to achieve sustainable development, human, physical and natural capital demands preservations. There is a debate that human development reflects on this idea that there should be an improvement in people well-being and they are given facilities to live their life with ease (Paraschiv et al., 2021). UNDP is one of the first organizations which proposed the idea of advancement in human development. Thus, it always managed to introduce variety of component in the area of social sustainability. Moreover, UNDP also shows continuous support to strategic vision of China regard social sustainability. UNDP also offers multiple advices on the situation that how present challenges such as aging society, inequality AI impact, ecological deficit should be addressed from the perspective of social sustainability. China, indeed, has become the global manufacturing factory (see Figure 2) due to its rapid economic growth. Thus, entire globe regards the country as a business opportunity. It is argued that the country has diverted spatial focus on social sustainability because it is the key driven factor for country to push it towards betterment (Wang et al., 2021).

Ever since its inception in 1949, China has experienced greater advancement in the area of social sustainability. In the year 1978, human development index of China was scored 0.410 while in 2017 it was 0.752 (Anwar et al., 2021). UNDP started assessing HDI trends in 90s and only one country jumped from low HDI to high HDI that was due to the progress in health care and education sector. At the beginning of its reform and opening phase, China already had high rate of social indices compared to low-income nations. High economic development brought upon due to the changes introduced in 1978 that accelerated social development growth. However, government institutions shifted their attention to acknowledge scarcities in other sustainability area and combined social development and environmental development in the year 2000 (Niaz et al., 2022). In 2002, target date was set which articulates that a society will become "overall moderately wealthy" by 2020. Unfortunately, the target was unable to achieve due to several challenges and they will likely to create an obstacle for 2030 goals too. Factors such as higher public expectation for better living standard, steady economic

growth, socio economic issues and high foreign tensions are creating hindrance for China to navigate the economy to its next development phase (Gasparėnienė et al., 2021; Jonah & Kanyangale, 2021; Wosiek, 2021).

In this context, eco-innovation methods have gained enough popularity at national and corporate level because of this ideology that industrial sector remarkably contributes to environment and also address social concerns. Eco-innovation plays essential role in limiting harmful effect of industry. On the basis of this concept, it can be implied that eco innovation can lead to strategic activities through which countries financing activities can be enhanced which results in social development. In addition to this, it is also argued by scholars that the

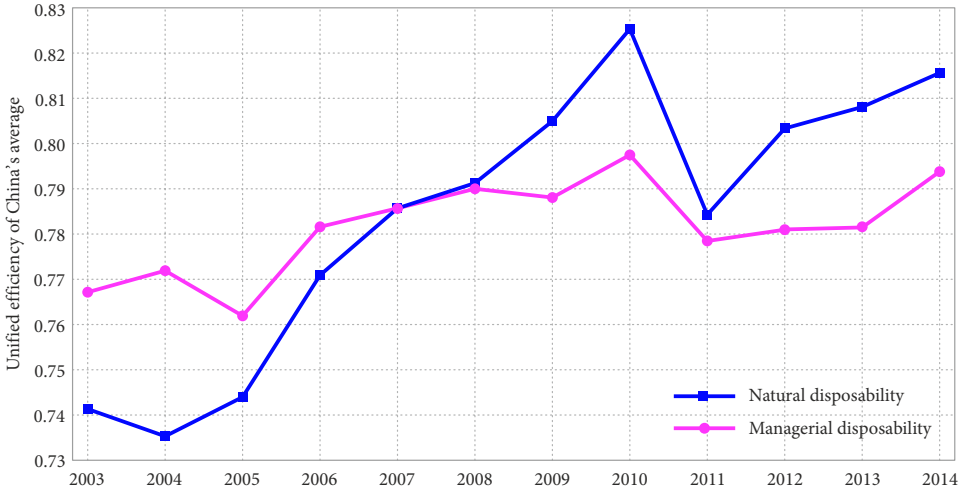
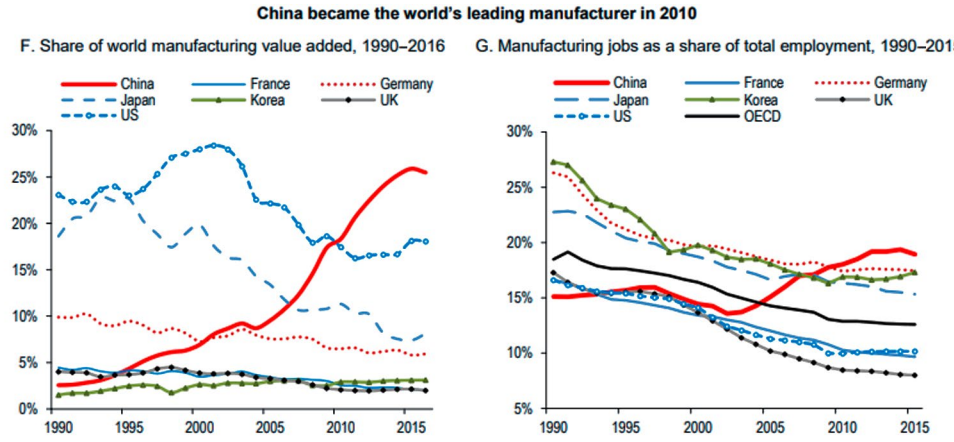


Figure 1. Social Sustainability in China



Note: Industry refers to mining & quarrying, manufacturing, energy (electricity & heat production & supply) and construction.
Source: OECD National Accounts database, World Bank World Development Indicators database, United Nations National Accounts Main Aggregates Database.

Figure 2. Manufacturing sector statistics of OECD Economies

replacing the conventional technologies with sustainable technology would help economies gradually to achieve sustainability idea. The idea which demands economies to consider those factors that are socially, environmentally and economically oriented. Utilizing renewable technologies in energy sector means less emissions and health complications, access to renewable electricity, hence, enhance inclusive growth. Thus, we can conclude that social sustainability is also an effective pathway to achieve SDGs, however, it essential to raise question that how sustainable technologies, eco-innovation and economic growth help in achieving social sustainability in the context of China (see Figure 1). Therefore, we document following question to answer it through strong empirical evidences.

Q. *What is the role of sustainable energy technologies, eco-innovation, economic growth in attaining social sustainability?*

This way the contribution of the study is threefold. It is one of the pioneers which extended the debate on social sustainability in the context of China. Concrete evidences will help the policy makers to look into the areas which are normally recognized as a strong environmental factor. Secondly, we propose an argument that although the limited studies have explored that said relationship, however, as per authors' knowledge, studies used simple ARDL techniques or other models to assess the long run and short run association. Contrary to this, the present study applied dynamic ARDL simulations of Jordan and Phillips (2018) which are known because of their proficiency to observe the actual changes in study predictors. Thus, the study contributes to literature by employing novel DARDL method to scrutinize the relationship.

The overall article has been structured in to pile of sections. Study gap and significance which has already been discussed in first part, literature review provides the further insights regarding the study variables. Following that, methodology is discussed in next section. Discussion, which is the 4th part of study highlight the contrasted evidences which provides the base to offered policy implications that are being presented in conclusion section along with some limitations.

2. Literature review

Since last decade, the world is increasing its efforts to control the adverse effects on the environment (Hussain et al., 2022). One of the major sources of these ecological changes is usage of traditional resource in energy production. However, in order to minimize its effect, the world is switching to renewable sources. Businesses have been under growing pressure in recent years to figure out how to run their operations in a way that minimizes their negative effects on the environment and society. This has motivated businesses and scholars to develop sustainable business practices (Alnabulsi & Salameh, 2021; Hansen et al., 2020). Ever since the UN report came reflecting on the association among society, resources and environment, the importance of sustainability gained a lot of recognition at global level (Joshi & Yenneti, 2020; Peternel & Grešš, 2021). While on other side, rapid technological changes have increased the energy demand. Since the countries are utilized traditional methods to fulfill the energy demand. Thereby, most suitable way to control these adverse ecological changes

is to produce energy from renewable resources like the solar system, and hydroelectric. Sovacool and Walter (2019), worked on hydroelectric energy production from military, poverty, economic growth, ecological changes and greenhouses gasses emission points of view. The study was conducted in OPEC countries in the time span of 1985 to 2014. Findings articulate that renewable energy production provides betterment to society and environment. Furthermore, Nzotcha et al. (2019) explored the selection of hydroelectric energy plants with a view to sustainability. It is exposed that the production of energy from renewable resources results in controlling ecological changes and sustainability. On the other hand, the selection of the site is the key to the attainment of sustainability in the production of hydroelectric energy.

One of the major concerns for the entire globe over the past few deceased is the ecological changes. These changes are adversely affecting every aspect of life. There have been significant ecological changes witnessed over the past 70 years. The amount of surface and air travel, as well as the use of oil and power, have all multiplied globally. One of the adverse effects is increasing global warming. The increase in activity is the consequence of both the approximately threefold increase in population and the fourfold increase in per capita GDP. The amount of energy used globally has increased seven-fold, mostly as a result of growing reliance on fossil fuels for transportation, industry, and construction. The fast expansion of structures and infrastructure is shown by the 30-fold increase in cement output. When compared to the pre-industrial baseline of roughly 280 parts per million, the rise in atmospheric CO2 levels looks moderate (Chang et al., 2022; Fang et al., 2022). The world is continuously looking for steps to control the effects of these ecological changes. One suitable way is the adoption of renewable energy production. In this context, Moriarty and Honnery (2020), looked into the new approach needed to tackle ecological and social sustainability. One of the major factors of ecological changes is energy production from traditional resources. The world is shifting to renewable energy. The production of energy from the solar system results in supporting ecological change as well as resulting in social sustainability. Similarly, Aldewachi and Ayağ (2022), also worked on the achievement of social sustainability in solar energy firms. This achievement will lead to support the ecological changes. The study was conducted in Turkey on solar energy production firms. The results of the study revealed that the production of energy from the solar system strongly affecting the ecological changes in a positive way and also results in the attainment of social sustainability.

The world is witnessing rapid changes in terms of innovation. These innovations are impacting every aspect of life (Marin-Garcia et al., 2022; Xiao et al., 2021). The ultimate aim of these innovations is to facilitate society through social sustainability. As Eco-Innovation is a new business approach which supports sustainability with the help of the entire business lifecycle while enhancing a company's performance as well as the competitiveness. Thus, implementation of any related eco-innovation in business will lead to sustainability (Demirel & Kesidou, 2019; Shafi et al., 2022). In this context, Orji et al. (2019), explored the challenges faced by the logistics industry during the application of eco-innovation with the view of the attainment of sustainability. The study was conducted in Nigeria. The study posited that quick and effective decisions must be made in order to get rid of the obstacles that are associated with social and environmental burdens. The study also shed light on few eco-innovation

methods that are suitable to bring sustainability in freight logistics. The authors also documented that Nigeria is currently facing major challenges in freight transportation firm due to limited fundings and less awareness regarding the financial benefits of ecological activities. Besides, lacking in technological infrastructure and resistance towards innovative method are also one of the major issues in such firms. For decision- and policy-makers in the freight logistics industry who want to include eco-innovation projects to achieve sustainability, these results will offer insight and instructions. Similarly, the manufacturing sector of any country is considered a pivot in the country's economy. This sector always needs to implement updated technology with the aim to be in the sustainability competition. Accordingly, Larbi-Siaw et al. (2022) explored the benefits of sustainable innovation in firm business performance by considering the trip bottom line concept. The study chose Ghana as a sampled country and targeted manufacturing firms only. The results of the study revealed that applicability of the eco-innovation in Ghana's manufacturing sector leads to betterment in the overall financial performance of the sector and results in social and environmental sustainability. Moreover, the triad of product, process and organizational eco-innovation may be used to significantly enhance social as well as environmental performance.

Every country in the world has the prime aim to bring prosperity to its country people's life by enhancing their standard of living. The only factor which makes it possible is economic sustainability. A financially stable country ensures all sort of social, and environmental sustainability; thus, social and financial sustainability is associated with each other. In this context, Sandberg et al. (2019) explored whether economic growth affect environmental sustainability which is a major part of social sustainability. The results revealed that economic sustainability helps the country to support all those factors which can bring social sustainability like the environment. As a result of global warming and poverty, industrialized and developing nations have made a commitment to take an active part in addressing pressing global concerns and achieving the goals of the 2030 Agenda for SD. Despite this, the UN states that we are still far from attaining sustainable goals five years after the agenda's introduction. Accordingly, Mendoza-del Villar et al. (2020), checked whether economic and social sustainability collectively leads to sustainability in Industry 4.0. Findings articulated that both social and economic sustainability is vital to support any industry either manufacturing or services in the country. In the case of Mexico, social and economic sustainability lead to bring sustainability in the selected Industry. Moreover, Apaydin et al. (2018), also explored whether social and economic sustainability can be achieved through hypo connectivity. The study taken the sample of 148 countries. The data for the year 2014 was collected and tested. Results displayed that rising economies were, in fact, the best at using digital content and infrastructure, followed by developing and advanced nations. However, compared to developing countries, developed countries' superior access to technology did not have the same socio-economic impact. Favorable legal frameworks and widespread individual ICT use in advanced economies also did little to support socioeconomic sustainability.

Social sustainability is one of the prime concerns of the world. Literature witnessed that the world is focusing on understanding the concept of sustainability. Although it researched a lot there is less attention paid to the achievement of social sustainability through social infrastructure (Shahzad et al., 2022). In this context, Grum and Grum (2020), explored whether

social infrastructure, and quality of country population life have any influence on social sustainability. Results exposed that, as a consequence, a model that depicts the connections between elements of social infrastructure (such as public infrastructure and utility equipment) and aspects inside the quality-of-life structure has been created (population, quality of life). The end result is a model that depicts the relationships between elements of social infrastructure (such as utility equipment, public infrastructure, essential items, and fundamentals) and, further, between elements of the well-being structure (population, quality of life). The ageing population in the world is presenting many challenges for the country. The rapid increase in population also leads the country to many crises like unemployment. Furthermore, the high intensity of population growth also leads to disturbing the social sustainability of the country (Gusmano & Okma, 2018; Skare & Soriano, 2021). In the future decades, the share of the population over 65 will rise considerably in both industrialized and developing nations due to the global trend toward longer life spans brought on by medical advancements and other causes. Ages over 65 have the greatest declines in death rates, and ages over 75 see the greatest increases in life expectancy. The number of old and disabled persons has increased in recent decades due to the expansion of the aforementioned age categories. The relationship between the aging population and sustainability is explored by Grazuleviciute-Vileniske et al. (2020). Findings emphasized the unique characteristics of the ageing population that need to be taken into account while designing and managing their living environment.

The social sustainability of any country is linked with economic betterment. If the country all the economic factors like inflation, exchange rate, and investment are working in a proper manner then it will lead to the betterment of the society which further affect social sustainability. Better governance can help the country perform all these factors as per their standard. In this context: Nițescu and Cristea (2020), explored the association between social sustainability in terms of risk in Romani situation. The data set of 25 central banks were collected through questionaries for the year 2007 to 2016. Findings exposed that governance is one of the factors which causes social sustainability through betterment in the economy like controlling inflation. Better governance is the biggest challenge for the continuation of the social sustainability. Investment plays a key role in the social betterment of the country. If all the economic factors like inflation are performing as per standard this will lead to investment which further will bring sustainability. In this context: Salite et al. (2021), explored whether inflation in the case of investment effect social sustainability. The study was conducted in Mozambique. The sample of 127 interviews was analyzed. It was revealed that the investment inclusive of the inflation factor affect social sustainability. Social and economic sustainability are associated with each other. In this context, Sudusinghe and Seuring (2020), explored whether social sustainability supports economic sustainability inclusive of the inflation factor in the case of the supply chain, particularly in Sri Lanka. The sample of 119 Sri Lankan manufacturing sector managers was assessed. It was exposed that actions taken by apparel manufacturers to inculcate social sustainability within the organization and in society have been found to have a positive effect on economic performance. In contrast to the ESSP, the ISSP generated a greater effect. Since this study is focused on just one developing nation, it should be expanded to include more nations in order to take into account the various institutional contexts in those nations. Based on the arguments we propose following hypotheses:

H1. *Sustainable technologies are associated with social sustainability.*

H2. *Eco-innovation is associated with social sustainability.*

H3. *Economic growth is associated with social sustainability.*

3. Research methodology

The present paper investigates the effectiveness of sustainable energy technologies, eco-innovation, economic growth, industrialization and inflation on social sustainability in China (see Table 1). The current article used secondary sources like CEIC Global Database, WDI and OECD from 1981 to 2020. The article has developed the study equation using understudy variables given below:

$$SS_t = \alpha_0 + \beta_1 EPSS_t + \beta_2 EPHS_t + \beta_3 ECI_t + \beta_4 EG + \beta_5 INF_t + \beta_6 IND_t + e_t, \quad (,1)$$

where: *SS* – Social Sustainability; *t* – Time Period; *EPSS* – Electricity production from Solar Sources; *EPHS* – Electricity production from Hydroelectric Sources; *ECI* – Eco-innovation; *EG* – Economic Growth; *INF* – Inflation; *IND* – Industrialization.

Table 1. Measurements of Variables (sources: CEIC Global Database; WDI; OECD)

S#	Variables	Measurement
01	Social Sustainability	Social sustainability index
02	Sustainable Energy Technologies	Electricity production from Solar Sources (% of total) Electricity production from Hydroelectric Sources (% of total)
03	Eco-innovation	Eco-innovation index
04	Economic Growth	GDP growth annual percentage
05	Inflation	Consumer price annual percentage
06	Industrialization	Industry value added (percentage of GDP)

The properties of data are being scrutinized though descriptive methods. The study with the help of correlation matrix also evaluated the strength and weakness among variables linkage. Moreover, the study utilized Phillips–Perron (PP) and ADF techniques to present unit root analysis. Expression for the tests is mentioned below:

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

Besides, the study also showcased co-integration results though (Westerlund & Edgerton, 2008) approach. This was necessary to do so as it helps researchers to identify the existence of co-integration. Expressions for the tests are stated below:

$$LM_{\varphi}\left(i\right) = T\hat{\varphi}_i\left(\hat{r}_i / \hat{\sigma}_i\right); \quad (3)$$

$$LM_{\tau}\left(i\right) = \hat{\varphi}_i / SE\left(\hat{\varphi}_i\right). \quad (4)$$

Aforementioned expression shows that refers to the estimate beside standard error, $\hat{r}_i^2$ that refers to the long-run measured variance, $\varphi_i(L) = 1 - \sum\varphi_{ij}L^j$ that refers to the scalar polynomial with L lag length, and ρ_i represents factor loading parameters vector.

The study also sheds light on the linkage between the variables by employing ARDL model. This approach has been used due to its major characteristic of the stationarity of the variables I(0) and I(1). This approach offers better insights in the short and long-run (Zaidi & Saidi, 2018). Finally, this approach has the characteristics to manage the effects of autocorrelation and heteroscedasticity (Nazir et al., 2018). The expression for the approach is mentioned below:

$$\Delta SS_t = \alpha_0 + \sum\delta_1\Delta SS_{t-1} + \sum\delta_2\Delta EPSS_{t-1} + \sum\delta_3\Delta EPHSS_{t-1} + \sum\delta_4\Delta ECI_{t-1} + \sum\delta_5\Delta EG_{t-1} + \sum\delta_5\Delta INF_{t-1} + \sum\delta_6\Delta IND_{t-1} + \varphi_1 SS_{t-1} + \varphi_2 EPSS_{t-1} + \varphi_3 EPHSS_{t-1} + \varphi_4 ECI_{t-1} + \varphi_5 EG_{t-1} + \varphi_6 INF_{t-1} + \varphi_7 IND_{t-1} + \varepsilon_t. \quad (5)$$

Finally, the current study also presents the relationships among the constructs by applying the newly established method called DRADL. This newly established approach was proposed by Jordan and Philips (2018) and it was introduced to overcome all related issues existing in ARDL model. The model is efficient enough to "estimate, predict and stimulate" the graph of real change in predictors and their impact on the dependent variables while maintain the remaining variables in equation. Moreover, the model also has the potential to plot negative or positive changes in the graph along with the estimation of long-run and shot-run association. It is also a reliable approach when the co-integration exists in the model (Sarkodie & Strezov, 2019). Below expression has been constructed for the approach:

$$\Delta SS_t = \alpha_0 + \sum\delta_1\Delta SS_{t-1} + \sum\delta_2\Delta EPSS_{t-1} + \sum\delta_3\Delta EPHSS_t + \sum\delta_4\Delta ECI_{t-1} + \sum\delta_5\Delta EG_t + \sum\delta_6\Delta INF_{t-1} + \sum\delta_7\Delta IND_t + \varepsilon_t. \quad (6)$$

4. Findings results

From Table 2, it is revealed that total no of observations was 40. It also displays that SS mean value was 68.799 followed by EPSS 1.431%, EPHS 18.428%, ECI 70.941%, EG 9.301%, INF 5.084% and IND 44.155%.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
SS	40	68.799	2.786	64.173	73.446
EPSS	40	1.431	2.288	0.0100	7.716
EPHS	40	18.428	2.334	14.624	24.573
ECI	40	70.941	5.977	61.092	80.911
EG	40	9.301	2.954	2.240	15.192
INF	40	5.084	5.860	–1.401	24.257
IND	40	44.155	2.616	37.843	47.557

The current study also presents the year-wise variable details using descriptive statistics by years. Findings showcased in Table 3 highlight that the highest value of SS was in 2020, the largest value of EPSS was in 2020, and the highest EPHS was in 1983. The study also displayed that the highest value of ECI was in 2020, the largest value of EG was in 1984, the highest value of INF was in 1994, and the largest IND was recorded in 2006.

Table 3. Descriptive statistics (Years)

	SS	EPSS	EPHS	ECI	EG	INF	IND
1981	64.173	0.010	21.195	61.092	5.113	5.415	45.970
1982	64.390	0.010	22.705	61.288	9.017	3.548	44.621
1983	64.564	0.010	24.573	61.909	10.770	1.680	44.229
1984	64.909	0.010	22.995	62.781	15.192	9.813	42.931
1985	65.105	0.010	22.491	62.902	13.431	7.946	42.712
1986	65.343	0.010	21.029	63.528	8.950	6.078	43.514
1987	65.581	0.011	20.112	64.039	11.657	7.234	43.318
1988	65.820	0.011	20.020	64.551	11.223	18.812	43.525
1989	66.058	0.011	20.244	65.062	4.206	18.246	42.496
1990	66.296	0.011	20.397	65.573	3.920	3.052	41.033
1991	66.535	0.011	18.460	66.084	9.263	3.557	41.487
1992	66.773	0.017	17.567	66.596	14.225	6.354	43.115
1993	67.011	0.017	18.108	67.107	13.884	14.610	46.177
1994	67.250	0.054	18.034	67.618	13.037	24.257	46.163
1995	67.488	0.306	18.908	68.130	10.954	16.791	46.751
1996	67.726	0.152	17.400	68.641	9.923	8.313	47.104
1997	67.965	0.259	17.254	69.152	9.237	2.786	47.099
1998	68.203	0.245	17.816	69.663	7.846	–0.773	45.798
1999	68.441	0.244	16.437	70.175	7.662	–1.401	45.360
2000	68.680	0.234	16.405	70.686	8.490	0.348	45.536
2001	68.918	0.225	18.733	71.197	8.336	0.719	44.793
2002	69.156	0.210	17.409	71.708	9.134	–0.732	44.451
2003	69.395	0.191	14.847	72.220	10.038	1.128	45.623
2004	69.633	0.179	16.045	72.731	10.114	3.825	45.900
2005	69.871	0.297	15.878	73.242	11.395	1.776	47.023
2006	70.110	0.387	15.206	73.753	12.721	1.649	47.557
2007	70.348	0.477	14.787	74.265	14.231	4.817	46.884
2008	70.586	0.860	16.878	74.776	9.651	5.925	46.971
2009	70.825	1.292	16.571	75.287	9.399	–0.728	45.957
2010	71.063	1.674	16.949	75.798	10.636	3.175	46.498
2011	71.301	2.138	14.624	76.310	9.551	5.554	46.529
2012	71.540	2.658	17.309	76.821	7.864	2.620	45.423
2013	71.778	3.565	16.731	77.332	7.766	2.621	44.177
2014	72.016	4.057	18.552	77.843	7.426	1.922	43.086
2015	72.255	4.857	19.070	78.355	7.041	1.437	40.841
2016	72.493	5.304	18.456	78.866	6.849	2.000	39.581
2017	72.731	5.907	18.766	79.377	6.947	1.593	39.852
2018	72.970	6.510	19.076	79.889	6.750	2.075	39.687
2019	73.208	7.113	19.386	80.400	5.951	2.899	38.587
2020	73.446	7.716	19.696	80.911	2.240	2.419	37.843

As discussed earlier, the correlation test has been performed to evaluate the strength and weakness among constructs. Table 4 indicated that sustainable energy technologies such as solar and hydroelectric, eco-innovation, economic growth, industrialization and inflation share a strong relation with social sustainability in China.

Table 4. Matrix of correlations

Variables	SS	EPSS	EPHS	ECI	EG	INF	IND
SS	1.000						
EPSS	0.799	1.000					
EPHS	0.558	–0.014	1.000				
ECI	1.000	0.799	–0.558	1.000			
EG	0.351	–0.539	–0.111	–0.350	1.000		
INF	0.428	–0.291	0.229	–0.427	0.332	1.000	
IND	0.261	–0.698	–0.457	–0.261	0.515	0.118	1.000

For the application of the appropriate model, the study presents the unit root analysis with the help of PP and ADF tests. The findings revealed that the SS, EPSS, EPHS, INF and IND are stationary at level. In contrast, the findings also revealed that the ECI and EG are stationary at first difference. Table 5 has shown these figures.

Table 5. Unit root test

ADF PP				
Series	Level	First difference	Level	First difference
SS	–2.111***	–	–2.773***	–
EPSS	–3.772***	–	–3.288***	–
EPHS	–2.782***	–	–2.009***	–
ECI	–	–4.928***	–	–5.544***
EG	–	–6.772***	–	–5.756***
INF	–2.810***	–	–3.443***	–
IND	–3.110***	–	–3.993***	–

The present article also displayed the co-integration test. Outcomes also exposed that the probability values are <5%, while the t-values are >1.96. These findings indicated exposed null hypothesis is rejected, and co-integration exists. Table 6 has shown these figures.

Table 6. Co-integration test

Model	No Shift		Mean Shift		Regime Shift	
	t-stat	p-value	t-stat	p-value	t-stat	p-value
LM_{τ}	–2.564	0.00	–4.902	0.00	–5.937	0.00
LM_{φ}	–2.673	0.00	–2.897	0.00	–5.774	0.00

Finally, the current study also presents the relationships among the constructs by applying the newly established method called DRADL. The results of this approach indicated that sustainable energy technologies such as solar and hydroelectric, eco-innovation, economic growth, industrialization and inflation are positively connected with social sustainability in China. Table 7 has shown these figures.

Table 7. Dynamic ARDL model

Variable	Coefficient	t-Statistic	Prob.
ECT	–3.102*** 3.900***	5.322 6.611	0.000 0.000
EPSS	2.891** 4.893*	4.904 3.093	0.000 0.012
EPHS	2.937*** 3.993***	2.901 5.888	0.017 0.000
ECI	1.333*** 0.673**	3.948 3.903	0.001 0.002
EG	0.091** 0.282**	2.679 2.302	0.023 0.031
INF	1.652** 1.649***	4.003 3.009	0.000 0.013
IND	3.546**	2.092	0.045
Cons	3.563**	2.946	0.016

Notes: R square = 58.423 Stimulation = 5000.

5. Discussions

The results indicated that electricity production from solar sources positively influences social sustainability. Findings are consistent with Campos-Guzmán et al. (2019), which shows that in the country where organizations are encouraged to gain electricity produced from solar panel systems, the firms utilize sustainable energy to meet the economic requirements to the largest possible extent. This results in the reduction of environmental pollution caused by business operations, the health of the stakeholders are saved, and they can enjoy a healthy social life. Thus, electricity production has a great contribution to social sustainability. Findings also support Rani et al. (2019) evidences which posits that the production of electricity from sustainable sources like the solar system help to carry the economic operation without creating health affecting smoke and wastes flowing into the water system. Hence, the economic practices, whether related to manufacturing or trading, do not adversely affect the health of the general people living in the same area. The protection of health enables people to carry out social activities with motivation and without sudden breaks. This leads to social sustainability. Results are consistent with Ahmed, Cary, Shahbaz, and Vo (2021), which examines the impacts of electricity from the solar system on social sustainability. This past study also confirms that electricity production from solar sources enables the economy to overcome environmental degradation and develop sustainable societies.

The results indicated that electricity production from hydroelectric sources positively influences social sustainability. Moner-Girona et al. (2021) study matches with current findings, which highlights that the increasing tendency to attain electricity by employing hydroelectric sources enhances the total sources of energy within the country. The availability of low-cost and less environmentally affecting energy overcomes social issues like the spreading of diseases and lack of resources. This social performance is sustainable. Results are supported with the prior evidences of Nowotny et al. (2018), which examines the impacts of electricity from the solar system on social sustainability. The study claims that the country where the electricity is produced from hydroelectric sources and transmitted to firms through grids. The firms prefer to employ energy-efficient technologies requiring renewable energy with low voltage power. In this way, manufacturing, infrastructure, and transportation are pollution free and help construct a sustainable society. Results show consistency with literary work of Lin and Zhu (2019), which claims that the firms which rely on electricity production from hydroelectric sources give an ecological-friendly production of goods and services. These goods and services assist people in meeting their needs without disturbing their future requirements. This determines a positive link between electricity production from hydroelectric sources and social sustainability.

The results indicated that eco-innovation positively influences social sustainability. These results agree with the literary work of Ijadi Maghsoodi et al. (2018), which states that economic activities have an impact on citizens' health and their activities. But the business firms which implement eco-innovation while undertaking economic practices reduce negative impacts on citizens' health and keep their activities smooth. Hence, the adoption of eco-innovation promotes social sustainability. Findings are consistent with Loia and Adinolfi (2021), which proclaims that the firms applying eco-innovation tend to employ eco-friendly technologies for the production and marketing of goods and services with an intention to bring improvement without damaging the people's interests. This assures social sustainability. Results are linked with Kuo and Smith (2018), which examines the role of eco-innovation in social sustainability. The adoption of eco-innovation in different business departments improves the business effectiveness there and reduces the negative environmental consequences. As a result, society may grow sustainably.

The results indicated that economic growth positively influences social sustainability, hence supported by the study of Mahmood et al. (2022), which highlights that the countries getting progress in economic growth can afford innovative technologies and eco-friendly systems. These technologies and eco-friendly initiatives minimize the environmental concerns of the public and give them progressive economic opportunities. This facilitates the achievement of social sustainability. These results agree with the literary work of Pan, Sinha, and Chen (2021). This workout is about economic growth's role in social sustainability. If the economy is making economic growth, sustainable energy generation projects are started, and increased source of clean energy helps the firm to overcome pollution due to increasing energy needs. The environment saved from pollution provides a context for people to live their social lives. These results are also in line with the study of -----, which also focus on the idea that the countries making higher progress in economic growth rate are able to bring eco-friendly improvement and achieve social sustainability.

The results indicated that inflation positively influences social sustainability. Findings are confined with Musarat et al. (2021). During the inflationary period, the government itself has huge financial resources and the ability to pay attention to carrying out developmental programs within the country in order to facilitate the economic and social life of the people. In this situation, the people living in the country can have good health and a better standard of living. So, inflation leads to social sustainability. Findings are consistent with Salite et al. (2021), which highlights that inflation leads to enhanced profits and motivates firms to employ eco-innovation in order to enhance the total production and marketing level. The adoption of eco-innovation while performing economic activities leads the economy to have higher environmental performance along with profits. In this condition, the companies' stakeholders have healthful environment, living & non-living resources of their use and therefore, they achieve sustainable social life.

The results indicated that industrialization positively influences social sustainability. These results agree with the study of Li et al. (2020). This past study explains industrialization determines social sustainability in the sense that it gives rise to economic innovation, technological development, infrastructure improvement, and enhanced life awareness. This improves social performance leading to social sustainability. Results are consistent with Barbieri, Di Tommaso, Pollio, and Rubini (2020), which investigates the impacts of industrialization on social sustainability. The study implies that the increase in industrialization enhances environmental awareness among people and the knowledge about the energy efficient processes and ecological activities. The enhanced environmental awareness develops sustainability in social development.

Authors who carefully read this study can learn much for future research because the present study makes a significant contribution to the literature. In many previous studies, the role of electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, and industrialization in social sustainability has been analyzed. But these literary articles have addressed the role of these factors in social sustainability separately. The current study makes a simultaneous analysis of the impacts of all these variables on social sustainability. Thus, it adds to the literature. Usually, in the existing literature, only the term sustainable energy technologies have been used for analyzing social sustainability. In the current study, the components of sustainable energy technologies like electricity production from hydroelectric sources and electricity production from solar sources have been taken to examine social sustainability. Moreover, little study has been done on the relationship between electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation and industrialization, and social sustainability for the Chinese economy. The present workout removes the literary gap by nexus these factors and social sustainability in China.

The current study has great empirical significance in emerging economies like China which are overpopulated and have a lot of social and environmental issues which do not allow the societies to grow well at a sustainable rate. The study gives a solution for establishing social sustainability. The study serves as a guideline for economists, social reformers, environmental regulators, and governments as it tells them how they must establish a sustainable society. The study conveys that policymakers must keep in mind to promote electricity production from solar sources to move society towards sustainability. Likewise, with effective environ-

mental and economic policies, electricity must be produced from hydroelectric sources so that with the use of sustainable energy, social progress can be sustainable. The study provides a guideline to social reformers and environmental regulators that they must struggle to create motivation for eco-innovation both at the social and economic level in order to achieve social sustainability. The current study provides guidelines to the regulators in making regulations related to maintaining social sustainability by using effective sustainable energy technologies and eco-innovation.

The government and economists must try to accelerate the rate of economic growth to encourage sustainable practices in order to provide the foundation for social sustainability. It is also recommended to policymakers that they must try to take benefit from the inflationary period for progress to social sustainability. Furthermore, the study suggests that industrialization must be encouraged within the country to enhance progress toward social sustainability.

6. Conclusions

The study was aimed at analyzing the impacts of sustainable energy technologies like electricity production from hydroelectric and solar sources, eco-innovation, and economic growth on creating social sustainability. It was also to analyze inflation and industrialization besides the electricity production from hydroelectric and solar sources, eco-innovation, and economic growth for determining social sustainability. The empirical quantitative from China was used to examine the impacts of electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, and industrialization on social sustainability. According to the study results, there is a position association between electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, industrialization, and social sustainability.

The results showed that if in a country, sustainable energy is produced in the form of electricity from hydroelectric sources, clean energy usage may increase in place of fossil fuels. This helps develop a healthy and prosperous society leading to social sustainability. The results also indicated that the increased production of electricity from solar sources increases the clean. The use of clean energy in performing business functions removes their impacts on people's wellbeing. Hence, social sustainability is possible. The results also indicated that the adoption of eco-innovation is useful to overcome the issues caused by businesses for people and create betterment in people's social life leading to progress in social sustainability. The study concluded that with the increase in economic growth, improvements are being made in the business resources and processes. Thus, direct or indirect negative impacts of economic practices on people's wellbeing are reduced, and social sustainability is achieved. The study highlighted that the inflationary change in the economy starts developmental activities and also motivates the business firms to bring improvement in their functions. In this situation, the people connected to business are kept saved, and their social wellbeing is sustainable. Furthermore, the study showed that the increase in industrialization enhances the manufacturing of technological tools and instruments, enhances the income level, and minimizes many rural issues. Thus, it brings a wonderful change in human life and overcomes the adversities caused by economic activities.

7. Policy implications

Moreover, the proposed policy directions also dictate that there is a need to upscale "socially and ecologically valuable innovative activities". However, it is only possible when changes are made in economic, social security systems. Besides, factors social and solidarity economy, community models are also known parameters to direct eco-innovation towards social sustainability. Moreover, income security systems, activation programmes can be helpful to trigger financial possibilities through which consumers and organizations can participate in eco-innovation activities in order to benefit the society. Economies currently are struggling hard to increase the social inclusion of distanced people while bearing the pressure to minimize social investment costs. The said difference highlights the two concepts of active social citizenship; self-determination type in which "the state offers support for social security and services, which enable self-determined active social citizenship 'in terms of choice and autonomy" and self-reliance type in which "the government pressures citizenship to become self-reliant and finance and organize their own social security and social services." In both cases, the effective one seems to be self-determination type because eco-innovation and sustainable technologies growth is clearly visible in situation. The plausible explanation is that the pressure which is in the second of citizenship might lead to negative consequences which China is not ready to face along with other obstacles. Welfare policies perspective is quite effectives and leads to this intrigued argument that innovative behavior develops when the concept of care is promoted without any force. Moreover, promoting sustainable innovation, and sustainable technologies also open avenues for scholars as it might lead to cultural change because of the constructive impact on humanity and environment.

8. Limitations

There are several limitations associated with the present study. These limitations are possible to be removed in further literature if authors apply better literary expertise. First, the current study checks the role of limited factors like electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, and industrialization in social sustainability. There are several other factors like CSR, ESG, green finance, environmental taxes, etc., which are influencing social sustainability. In a comprehensive guideline, the authors are recommended to include more factors in the analysis of social sustainability. The empirical data for providing evidence of the relationship between electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, industrialization, and social sustainability were acquired from China. The data from China alone cannot be sufficient for providing equally valid studies for all countries. The future scholar must debate electricity production from hydroelectric and solar sources, eco-innovation, economic growth, inflation, industrialization, and social sustainability with evidence from multiple countries. The data in support of the study hypotheses regarding electricity production from the hydroelectric and solar sources, eco-innovation, economic growth, inflation, industrialization, and social sustainability relationship is restricted to a limited time period. In the future, the authors must collect the required data for the variable for a longer period so that the study's reliability can be enhanced.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The author declare that they have no competing interests.

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