RETRACTED: Financial Consideration of Energy and Environmental Nexus with Energy Poverty: Promoting Financial Development in G7 Economies

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Energy and environmental concepts have been extensively studied in the past. However, these studies often lacked integrated analysis of energy, monetary, public, and ecological aspects to assess energy and environmental issues. This article provides analyzation of the G7 nations' qualitative, social, cultural, and health achievement in the energy poverty indexes. These include the energy economics and climate change of energy poverty, by using DEA like a composite indicator. The G7 countries' combined energy consumption is equal to 34% of the world's total, whereas the GDP is 50% of the global total. As a result, this article develops a comprehensive series of energy, financial, societal, and environmental indicators that are up to date. Such indicators are utilized to assess energy financial, societal, and EPI using a mathematical composite indicator. Canada has the greatest EPII score, indicating that it can deal better than the other G7 countries with energy independence, productivity expansion, and social impact, and France's and Italy's the second tier. While Japan has a 0.50 EPI grade and the United States will have the lowest, the G7 countries are growing faster. Finally, we propose a policy framework for enhancing the research area. The energy, societal, and EPI were created by combining these elements. In terms of energy independence, economic growth, and sustainability practices, Canada beats the other G7 countries according to the data. France and Italy are in the 2nd and 3rd places, respectively. Despite having a higher level of economic development than the G7 countries, Japan has a 0.50 Environmental Performance Index rating, whereas the United States has a minimum average Environmental Performance Index rating. Finally, in order to improve the study's subject, we propose a policy framework.

Keywords: energy finance, financial indicator, ecological perspective, climate change, energy poverty

INTRODUCTION

Energy consumption has become the dominant drivers of financial development throughout the last century, allowing millions of citizens to climb out of poverty (Al-mulali, 2011; He et al., 2010). Due to its simple accessibility and unregulated use, energy has also been recognized to have a role in associated environmental challenges. The World Energy Council (WEC) annually produced a report

utilizing an energy syllogism (Chen et al., 2019) to measure the performance of energy, commercial, monetary, and environmental performance (World Energy Council and Oliver Wyman, 2018). The criteria for evaluating trilemma competency assessments are calculated in this study. The ETI is a statistical method that assesses the performance of the region's government and corporate leaders. It focuses on the regions where financial growth is critical (Anser et al., 2020f; Anser et al., 2020d).

The ETI is found to be the ideal way to rate countries based on their ability to build an acceptable, reliable, and cost-effective energy infrastructure (Aslan et al., 2018). It is determined by analyzing the ETI study's three high-performing elements. Three contradicting assessments of the trilemma index are assessed using a secure, logical, and generally achievable energy strategy (Radovanovi et al., 2017). This research noted the optimum slack in greenhouse gas emission for each nation using the factor greenhouse gases emission per capita, indicating that every nation may reduce emissions if they meet the standard. If the attained level meets the standards, every nation can eliminate about 90% of greenhouse gas emissions, meaning that many nations in the group have weak environmental performance (Zhe et al., 2016). These nations, on the other hand, have a huge opportunity to reduce GHG emissions. Since both factors have comparable properties, the erroneous output slack and beneficial inputs slack minimization can be optimized through organizational attempts. Ireland and Turkey, on the other hand, have stronger environmental performance because of higher GDP development, whereas the remaining nations have identical GDP development characteristics. Due to higher greenhouse gas emissions, worse energy efficiency, poorest renewable metrics, and GDP development, this research reveals that none of the area's states can be used as a model for environmental performance. Furthermore, to classify the nations, a relevant comparison can be made (Chandio et al., 2020; Baloch et al., 2020; Iram et al., 2020b).

Recent research has sought to quantify environmental efficiency using various energy ways as input variables, with pollutants or some other environmental effect serving as an undesirable output. For instance, A. Charnes et al. (1978), Abraham Charnes et al. (1978) used the DEA method to calculate this link, while Boyd and Färe (1984) applied the CCR framework, and Banker et al. (2000), Banker et al. (1984) proposed the BCC framework. Kong and Tongzon (2006) proposed an SBM that accepted output and input as slack owing to angles and radial selection, while Shephard (1978) recommended a distance function method for this objective. This was, therefore still unable to remedy the efficiency issue, which resulted in an unsatisfactory output. Charnes et al. (1994) devised a Malmquist index to solve this problem (M). Then Solow (1957) introduced a DDF that used the DEA approach to create the ML. The TFP score and measured environmental efficiency by using pollutant emission as a function of undesired output. Du et al. (2018) proposed structure Luenberger (L) as a producing creative index for productivity measures.

The energy economic and environmental concerns linked with energy poverty: social development linkage from the G7 countries is assessed in this study. This research will look into the contribution of energy financial and ecological advancement,

as well as an effective managerial system for improving energy efficiency and reducing concentration, as just a manner forward toward emerging economies that are struggling to minimize the manufacturing costs by improving energy efficiency. The DEA technique was used to find the solution for improving energy efficiency in emerging economies, with the help of nations that had implemented improvements. It is one of the first empirical projects of its sort, involving power sector improvements to enhance energy efficiency in the longer term.

DATA AND METHODOLOGY

System of Indicators

The most crucial step in creating a meaningful and comprehensive energy, financial, and Environmental Performance Index is to create indicators. If metrics are gathered and examined properly, they might impart valuable information about energy, financial, and environmental issues. Additionally, these indicators deliver practical tools for policymakers to assess, analyze, and compare different countries' trends (Nardo et al., 2005). The construction of indicators has been divided into four categories including energy, economic, environment, and social indicators (Asif et al., 2020; Sarker et al., 2020; Iram et al., 2020a; Tehreem et al., 2020). Environmental performance is directly associated with energy since this sector is the major contributor to environmental degradation. The creation of indicators is the most important stage in constructing a useful and complete energy, economic, and Environmental Performance Index. If indicators are correctly collected and analyzed, they can provide meaningful information on energy, economic, and environmental challenges.

Energy Self-Sufficiency

The energy self-sufficiency ratio translates a country's capability to meet its national energy demand (Yao and Chang, 2014; Vera and Langlois, 2007). Energy self-sufficiency is a benefit-type statistic, meaning that the higher the number, the better; the mathematical formula is presented in **Equation 1**:

$$E_{suf} = \sum_{j=1}^{n} E_j w_j, \qquad (1)$$

where E_j represents the energy self-sufficiency ratio of energy, defined in **Eq. 2**, and w is the fossil energy portion j.

$$E_j = \frac{E_{con} + (E_{exp} - E_{imp})}{E_{con}} \times 100\%, \qquad (2)$$

where E_{con}, E_{exp}, and E_{imp} are the energy consumption, export, and imports of the fossil fuel j (Lombardi and Schwabe, 2017; Kemmler and Spreng, 2007).

Energy Dependency

It is a noteworthy fact that the high-energy dependency intrinsically generates high energy security threats (Patlitzianas et al., 2008; Turton and Barreto, 2006; Vera and Langlois, 2007). Countries dependent on imported energy are considered energy-insecure and climate-vulnerable since their economy is strongly dependent on

price fluctuations and the economic growth may weaken due to discontinuation in the energy market (Löschel et al., 2010; Greene, 2010).

$$Energy\ dependence = \frac{TPE_{con.} - TPE_{prd.}}{TPE_{con.}}, \qquad (3)$$

where $TPE_{con.}$ is the total primary energy consumption and $TPE_{prd.}$ is the total primary energy production.

Diversification Index of Energy Dependency

The diversification index of energy dependency helps diversify the energy imports, and its values mean that the country is capable of diversifying their resources (Tapia et al., 2016; APERC, 2007; X. Wang et al., 2018). Country risk factors have been added to the diversification index of energy dependency as is shown in **Eq. 4**:

$$DIVI = HHI - PE \times DEP_i = DEP_i \sum_{i=1}^{N} W_{ij}^2 \times \frac{1}{PE} \times CR_i, \qquad (4)$$

where DIVI is the diversification index, $W_{IJ} = \frac{X_{ij}}{\sum X_{ij}} X_{ij}$ is the percentage of energy suppliers j in the country's overall energy importation i, DEP is energy dependency on energy suppliers, W denotes the Herfindahl–Hirschman Index (HHI), P.E. is potential exports, and CR is the country's risk calculated by International Country Risk Guide (ICRG). Various researchers used the Shannon–Wiener index for this indicator (Shannon, 1948).

Energy Consumption

Energy consumption is considered a suitable indicator for measuring sufficient energy supply for human welfare (Cohen et al., 2011). Energy consumption is influenced by financial growth, population, energy structure, technological progress, industrial structure, urbanization, and industrialization level (Yousaf et al., 2020; Tehreem et al., 2020; Wasif Rasheed and Anser, 2017; Xu et al., 2020). Economists' groups encourage increasing energy consumption, while environmentalists discourage higher energy consumption, mediate between these two lobbies, reduce energy consumption, and do not negatively affect the economy; the latest energy policies strongly bet on energy efficiency (Martinez and Ebenhack, 2008). Countries at different economic development stages are considerably intended toward different energy sources, while energy consumption is also considered as mutually agreed consensus considering a cost-type indicator (Cohen et al., 2011; Sovacool and Mukherjee, 2011; Ang et al., 2015).

Carbon Emission Index

The following equation can be used to calculate the carbon emission index for every unit of energy used:

$$CE_{CO2} = CO_{emi}/E_{Con}, \qquad (5)$$

where CE_{CO2} is the amount of carbon dioxide emitted per unit of energy consumed (H. Wang et al., 2018), C_{emi} is CO_2 emission, and E_{Con} is the total energy consumption.

Carbon Emission Intensity

$CO2$ emissions are mostly released by the energy industry [xx]. The fuel usage (Yuan et al., 2008; Filipović et al., 2015) can be calculated as given in **Equation (6)**:

$$CE_{ity} = C_{emi}/GDP. \qquad (6)$$

Renewable Energy Sources

The sustainable energy proportion of total power generation in the national energy mix is used to calculate the RES indicator (Muneer et al., 2007). The main benefits of RES are linked to the environment and energy independence, but on the other side, they create many issues in terms of energy management due to their non-predictability. RES increases the sufficient supplies of green energy insignificant problem due to increasing concerns of dependency on imported energy supplies (Verbruggen, 2008; Apergis and Payne, 2010). In fact, RES ensures and enhances the diversification of energy sources. By using local energy production, it enhances energy efficiency (Lund and Mathiesen, 2009; Wolde-Rufael and Menyah, 2010; Scarlat et al., 2015). It is regarded as a kind of utility indication as follows:

$$Renewable\ share = \frac{Renewable\ electricty\ generation}{Total\ electricty\ generation}. \qquad (7)$$

Gross Domestic Product per Capita

GDP per capita is a standard indicator to measure economic growth. Despite many controversies, it is still deemed necessary for assessing economic prosperity and citizens' well-being (Lambiri et al., 2007; Konstantinaviciute and Bobinaite, 2015). GDP per capita is considered a benefit-type indicator.

GDP Productivity

GDP productivity is associated with the energy and economy relationship (Wang, 2011; Fiorito, 2013) as follows:

$$GDP\ Productivity = \frac{GDP}{Energy\ Production}. \qquad (8)$$

Human Development Index Score

The social indicators can be investigated by the measurement of the well-known Human Development Index (HDI). The HDI guarantees that the final requirements for assessing a country's social and economic progress are attained. Human Development Index represents differentiate national policies' choices, having two countries with the same GNI per capita come up but different human development outcomes. The HDI took into account social factors such as a lifetime of happiness, education, and a good quality of living (Liu et al., 2020; Lin et al., 2020; Jun et al., 2020). The HDI is the geometric aggregation of normalized social indicators. The HDI is a comprehensive representation of social elements of human development, even though it does not cover human security, poverty, and endowment (Pasqualetti and Sovacool, 2012; Kemmler and Spreng, 2007).

Ratio of Forest Area

The ratio of forestry indicator is significant to measure the environmental condition and environmental degradation, and relatively it is easy to calculate. Consequently, the United Nations included this indicator to assess and monitor the performance of MDG (Radovanović and Filipović, 2015; Hughes, 2009; Laponche and Tillerson, 2001). Data from 2001 to 2016 for all the indicators were accessed by the World Bank database (The World Bank Data, 2018), OECD accounts data files (World Bank Data Base, 2018), International Energy Agency (IEA, 2017), U.S. Energy Information Administration (U.S. Energy Information Administration, 2017), United Nations human development index report 2017, European Union data set, and BP Statistical Review (B.P. Statistical Review, 2017).

Methodology

The use of mathematical composite indicators is the next important step once the metrics framework has indeed been built. Composite indicators are defined as economy, social, and the environment from a technical standpoint. Composite indicators may be used to evaluate nations' energy performance and carbon emissions at the national level, presenting useful data to policymakers in global negotiations. MCDA and DEA are two of the most common methods for weighing and consolidating of a well-knownnetwork of comprehensive indicators, according to previous research (Zhou and Ang, 2008). The most popular and well-known MCDA aggregation technique is widely used technique (Kang, 2002; Esty et al., 2005; Ebert and Welsch, 2004; Ebert and Welsch, 2004; Zhou et al., 2006; Ebert and Welsch, 2004; Ebert and Welsch, 2004; Ebert and Welsch, 2004; Ebert and Welsch, 2004; Ebert and Welsch, 2004; Diaz-Balteiro and Romero, 2004). We utilized the DEA-like WP technique to aggregate those indicators based on the conclusions of Zhou and Ang (2009), Zhou et al. (2010). The MCDA technique has been heavily criticized due to the subjectivity with which weights are assigned to indicators. Zhou and Ang (Zhou et al., 2006) addressed this issue by extending a DEA-like model that holds the properties of balanced combination as follows:

$$gS_j = \max \prod_{k=1}^{n} x_{jk}^{gw_k}$$
$$s.t. \prod_{k=1}^{n} x_{jk}^{gw_k} \le e, \quad j = 1, 2, ..., m \qquad (9)$$
$$gw_k \ge 0, \quad k = 1, 2, ..., n,$$

where x_{jk} indicate the value of country j with respect to indicator k, gS_j denote the best performance of aggregated score for country j, and gw_k indicate the best set of weights. Afterward, another DEA-like model is presented as follows:

$$bS_j = \min \prod_{k=1}^{n} x_{jk}^{bw_k}$$
$$s.t. \prod_{k=1}^{n} x_{jk}^{bw_k} \ge e, \quad j = 1, 2, ..., m \qquad (10)$$
$$bw_k \ge 0, \quad k = 1, 2, ..., n.$$

Contrary to **Eq. 9**, **10** allocates the worst set of weights to underlying indicators or sub-indicators. bS_j indicate the poor score of region j, and bw_k show the worst set of weights allocated to underlying indicators or sub-indicators. **Eq. 9**, **10** are two non-

linear equations and require a bit of effort in computations due to the difficulty of non-linearity to solve them. Therefore, we get their corresponding and equivalent linear equations by taking their natural logarithm. The non-linear equations can be transformed as follows:

$$gS'_j = \max \sum_{k=1}^{n} gw_k \, x'_{jk}$$
$$s.t. \sum_{k=1}^{n} gw_k x'_{jk} \le 1, \quad j = 1, 2, ..., m \qquad (11)$$
$$gw_k \ge 0, \quad k = 1, 2, ..., n$$

$$bS'_j = \min \sum_{k=1}^{n} bw_k x'_{jk}$$
$$s.t. \sum_{k=1}^{n} bw_k x'_{jk} \ge 1, \quad j = 1, 2, ..., m \qquad (12)$$
$$bw_k \ge 0, \quad k = 1, 2, ..., n,$$

where $x'_{jk} = \ln(x_{jk})$, $gS'_j = \ln(gS_j)$, and $bS'_j = \ln(bS_j)$.

Since these two indexes are presented based on best and worst sets of weights, it is reasonable and mathematically symmetric in nature to aggregate them to develop an overall composite index to aggregate the underlying indicators for performance assessment. **Eq. 13** combines gS'_j and bS'_j to construct an EPII as follows:

$$EPI_j(\lambda) = \lambda \cdot \frac{gS'_j - gS'_{\min}}{gS'_{\max} - gS'_{\min}} + (1 - \lambda) \cdot \frac{bS'_j - bS'_{\min}}{bS'_{\max} - bS'_{\min}}, \qquad (13)$$

where $gS'_j = \ln(gS_j)$, $bS'_j = \ln(bS_j)$, $gS'_{\max} = \max\{gS'_j, j = 1, 2, ..., m\}$, $gS'_{\min} = \min\{gS'_j, j = 1, 2, ..., m\}$, $bS'_{\max} = \max\{bS'_j, j = 1, 2, ..., m\}$, $bS'_{\min} = \min\{bS'_j, j = 1, 2, ..., m\}$, and $0 \le \lambda \le 1$ is a variable for modifying and controlling. Model (13) is a minimum–maximum linear scaling pattern with a variable of λ within the range [0,1]. If decision-makers do not have a specific preference, all fundamental indications $\lambda = 0.5$. If gS_i is equal to 1, the CI_i bS_i becomes a normalized explanation of gS_i, and if bS_i is equal to 0, it becomes a normalized description of bS_i. Model (13) generates more surrounding CS, which can easily manage building indices, as a result of its virtue. The admirable features of CS_i are met. In models (16) and (17), CI_i is unit invariant, (ii) $0 < CI \le 1$ and (ii) CI_i is symmetric with regard to the right-hand side of the requirements (17). The feature of point 1 translates into the model limitations (11) and (12); if one is replaced with some other quantity, the CS remains unchanged.

Now there is the issue of disregarding all indications (zero weight) or categorizing them as overweight or underweight. Weights have the characteristic of being flexible in how they are assigned, and there are no limitations on how weights are assigned to underlying indications. In these cases, it is likely that any sub-indicators will be disregarded throughout the aggregate process. The weight limitation is a typical technique in building the composite index to guarantee each indicator's participation in the aggregation purpose. As a result, the weights of each sub-indicator are restricted as follows:

$$L_k \le \frac{w_k x'_{jk}}{\sum_{k=1}^{n} w_k x'_{jk}} \le U_k, \quad k = 1, 2, ..., n, \qquad (14)$$

TABLE 1 | Average score of individual indicators.

Country	EC(koe capita)	HDI	PES (million ton)	Renewable %
The United Kingdom	3125.98	0.897	16.876	07.98
The United States	3348.98	0.887	6.8975	07.986
Japan	2876.28	0.876	3.8780	05.9876
Germany	6487.50	0.910	33.9867	13.2438
France	3897.90	0.812	6.2133	12.70
Italy	3123.45	0.865	13.0990	15.09
Canada	7934.78	0.908	261.876	20.09

where L_k and U_k show the underlying sub-indicator, respectively, in order to generate EPI and fulfill the property of $0 \leq \lambda \leq 1$. The values of L_k and U_k can be obtained by expert's specific choice. Cherchye et al. (2007) pointed out that the obtaining weights through experts' choice is easier and more practical. We allocate $L_k = 0.05$ and $U_k = 0.20$, and the environmental efficiency index is found to be in the range of 5–20%.

RESULTS AND DISCUSSION

Individual Indicator Score

The energy consumption (kilo oil equivalent) figures vary from 8120.45 (koe) to 2889.54 (koe), according to the findings. Canada has the greatest energy consumption at 7934.67 (koe), followed by Germany at 6487.50 (koe), and Japan has the least energy consumption at 2876.28 (koe) between the G7 nations.

From an economic point of view, there is a strong correlation between energy consumption and financial development. At the same time, the environmental group discourages higher energy consumption due to inverse relationships. **Table 1** shows that Japan considerably contains the lowest energy consumption while higher HDI. Higher energy usage is in line with energy equality, availability, and cost. The human development index score shows that Germany has the highest HDI score, 0.910, followed by the United States 0.883, and Canada has 0.910, while Italy has the lowest HDI score of 0.873.

Primary energy supply values range from 267.19 to 4.64. Canada shows the highest value of 482.79 of primary energy supply, followed by Germany 34.87, while Japan shows a minimum value of 4.64. Renewable energy supply values range from 22.03 to 6.31%. Canada has the highest value, 22.03%, followed by Italy at 16.52% and Germany at 14.21%, while Japan has minimum values of 6.31%. Conversely, in G7 countries, the improvement of energy sources in Germany and France to consumption in power-intensive manufacturing got off to a comparatively delayed start. This makes Germany and France to exceptionally increase energy intensity levels compared to other G7 countries. As for the environmental index, Canada and Germany top with 0.64. At the same time, Japan shows a minimum of 0.34, even though Japan has the lowest CO_2 emissions, while the environmental index incorporates carbon emission and carbon intensity environmental. The findings are consistent with Wasif Rasheed and Anser (2017), Xu et al. (2020), Ahmad et al. (2020).

The energy intensity levels vary from 0.69 to 0.39, according to the results. **Table 2** indicates that Canada has the greatest energy intensity of 0.69, while the United Kingdom and the United States have the lowest energy intensity of 0.39. Regarding energy intensity values, Canada has the best score and is considered the best performer, while the United Kingdom and the United States lie in the lowest performing countries. GHG emission per unit of energy use varies between 1356.22 and 73.670. Canada has the greatest GHG emissions per unit of energy consumption, at 1356.22, followed by Italy at 297.51, and France has the lowest, at 73.67 (World Bank, 2015).

Financial development rates vary from 2.56 to 0.73 percent. The United States has the greatest economic development of 2.56, while Italy has the lowest at 0.73. Currently, an environmental crisis necessitated the implementation of major regulations to guarantee long-term sustainability in order to preserve the environment from climate change and other degrading issues. The level of energy intensity in transition nations has been higher than the level of economic output over the last 20 years. There are considerable differences in a shift of economic activities and the enhancements in greenhouse emissions. Between 2000 and 2016, the average energy intensity of G7 economies decreased, owing to increased energy efficiency and a move toward renewable energy in economic and industrial operations, as well as a focus on carbon reduction measures (Alemzero et al., 2020b; H. Sun et al., 2020; Alemzero et al., 2020a).

Overall Composite Index Score

In **Table 3**, the total EPI value for each nation is calculated, as well as the rationale for displaying all states' EPI score. In 2001, Canada had the maximum Environmental Performance Index score of 0.72, and in 2016, it had the minimum rating of 0.64. In comparison to other G7 nations, self-reliance, financial growth, and environmental performance are more important. Fewer incorrect outputs while producing greater financial outputs, such as self-energy sources, greater financial output, and lesser environmental emissions, are all indicators of environmental success. **Table 3** indicates that France and Italy are ranked second and third, despite having Environmental Performance Index scores of 0.72 and 0.62 in 2008 and 2001, respectively, while not having to have sound and adequate energy supplies and sustainable environmental EPI values. The maximum value for France was 0.72 in 2008, up from 0.61 in 2003, while the best value for Italy was 0.62 in 2001, down from 0.53 in 2016. With an Environmental Performance Index value of 0.50, Japan ranks in second. The United Kingdom, the United States, and Germany

TABLE 2 | Average score of individual indicators.

Country	Energy intensity	GHG (kg/capita, 000)	GHG per unit of EC	G.D.P. Growth
The United Kingdom	0.39	9.09	222.89	1.09
The United States	0.39	8.576	88.450	3.09
Japan	0.52	11.40	321.70	1.09
France	0.45	13.02	68.567	2.04
Italy	0.52	14.09	289.71	0.56
Canada	0.69	22.09	1289.98	3.08

TABLE 3 | Overall composite index score.

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
The United Kingdom	0.50	0.42	0.50	0.44	0.44	0.42	0.39	0.46	0.42	0.42	0.43	0.39	0.38	0.42	0.42	0.38
The United States	0.48	0.46	0.43	0.39	0.41	0.42	0.39	0.39	0.37	0.38	0.35	0.38	0.35	0.39	0.41	0.34
Japan	0.61	0.57	0.56	0.55	0.52	0.49	0.49	0.47	0.44	0.44	0.47	0.49	0.47	0.44	0.45	0.48
Germany	0.68	0.67	0.61	0.66	0.63	0.68	0.69	0.72	0.71	0.69	0.68	0.69	0.71	0.69	0.66	0.62
France	0.54	0.52	0.52	0.46	0.47	0.46	0.44	0.51	0.47	0.47	0.48	0.47	0.46	0.51	0.51	0.39
Italy	0.62	0.61	0.55	0.57	0.54	0.59	0.6	0.6	0.59	0.57	0.56	0.57	0.59	0.57	0.54	0.53
Canada	0.72	0.71	0.65	0.67	0.65	0.70	0.71	0.71	0.70	0.68	0.67	0.68	0.70	0.68	0.65	0.64

FIGURE 1 | Overall EPI score.
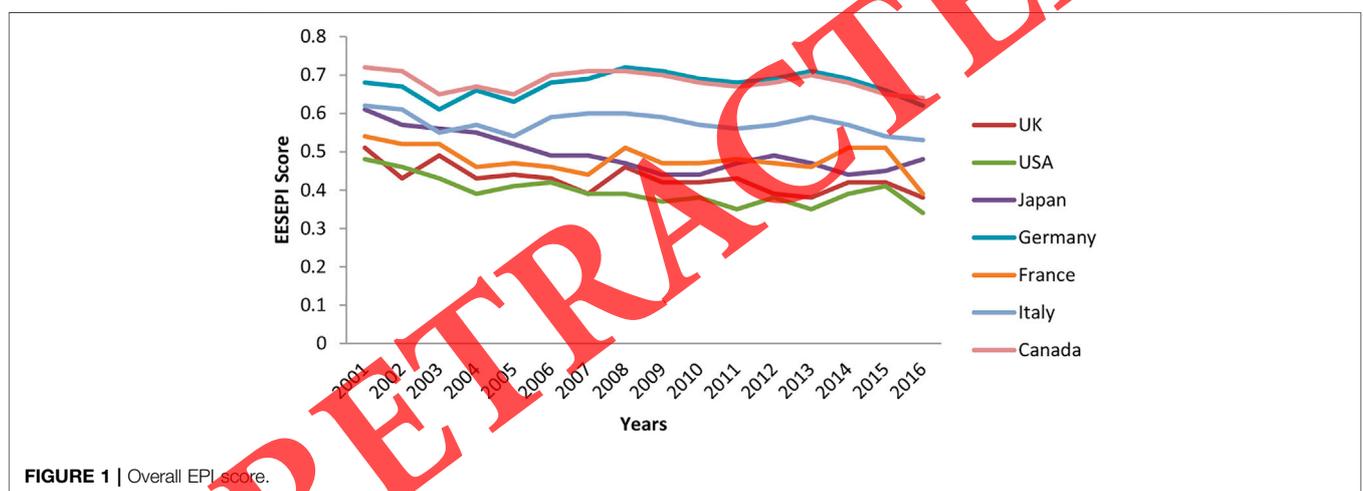
had Environmental Performance Index ratings of 0.43, 0.40, and 0.67, respectively.

However, comparing and ranking countries based on their average EPI scores, we opted to scrutinize each country's EPI and individual indicators score from 2001 to 2016. The EESEP scores in the region during the periods of 2001–2016 are shown in **Figure 1** shows Canada and Germany comparatively showed a smooth EPI score between 0.69 in 2001 and 0.74 in 2016. Japan's score dropped gradually from 0.65 in 2001 to 0.44 in 2010. A related direction we observed in the case of the United States is as follows: increasing energy consumption could justify the decreasing score from 2001 to 2010 in the EPI. Italy's EPI score has considerably reduced from 0.62 in 2001 to 0.53 in 2016, which may create an alarming situation even though Italy lies in a better situation similar to Germany and Canada than other

countries like the United States and the United Kingdom. However, it still requires significant efforts to cope with climate change concerns, including strengthening economic development.

Overall, the United Kingdom and the United States show a decreasing score, which indicates poor performance during the periods, while Germany and Canada situation is worse than other countries, which has the worst EPI values in the country. France, also being top in the ranking, reveals a better efficiency, which implies that the country is on the right track to maintain the emissions to produce economic output, while the country had the lowest CO2 emissions among the G7 counties, ensuring the efficient consumption of their resources to generate economic growth. Italy also lies at the favorable ranking point, signifying its positive trend in increasing economic production, consuming fewer resources without

TABLE 4 | Sensitivity analysis of composite index score.

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
The United Kingdom	0.47	0.40	0.41	0.41	0.40	0.50	0.49	0.40	0.40	0.45	0.40	0.49	0.42	0.49	0.50	0.49
The United States	0.45	0.41	0.41	0.42	0.42	0.42	0.54	0.42	0.41	0.46	0.43	0.42	0.43	0.51	0.51	0.41
Japan	0.57	0.51	0.52	0.53	0.51	0.49	0.56	0.46	0.47	0.42	0.42	0.53	0.50	0.50	0.50	0.50
Germany	0.69	0.63	0.62	0.62	0.60	0.65	0.70	0.70	0.75	0.69	0.68	0.70	0.72	0.69	0.72	0.59
France	0.55	0.52	0.59	0.42	0.48	0.49	0.59	0.52	0.49	0.49	0.50	0.47	0.50	0.49	0.59	0.61
Italy	0.61	0.61	0.52	0.51	0.55	0.51	0.50	0.60	0.56	0.57	0.57	0.52	0.61	0.49	0.62	0.60
Canada	0.71	0.71	0.61	0.61	0.69	0.71	0.70	0.72	0.71	0.69	0.69	0.78	0.69	0.69	0.71	0.70

increasing pollutant emissions. The United Kingdom has an averages score of 0.45, which shows that country is not performing well even though it has good environmental protection policies, that is, increasing concerns about renewable energy. Japan shows a smooth and then increasing trend of emissions, while Japan's economic situation lies among the world's largest economies. Among the G7 countries, Japan comparatively holds a good position for energy consumption, GDP, and CO_2 emission behind Germany, France, and Canada, while outperforming as compared to the United Kingdom and the United States.

Germany has the wealthiest economy in Europe. The world's leading power the United States performs well in terms of economic output, despite its significant and rapid economic improvements. The CO_2 emission levels lag behind it, among the other countries in G7 countries.

Canada, top in the ranking, includes self-sufficient energy resources, a larger share of renewable energy consumption, a stable economy, and a sufficient investment in research and development investments. Our research is aligned with a report about climate change subsidies published by Thomson Reuter Foundation in 2018, and the recent research scrutinized at G7 countries by using transparency, pledges, and commitments. The results reveal their progress toward ending the consumption, shore up, and generation of fossil fuels. Overall, France has ranked the top having a score of 63, followed by Germany at 62, the United Kingdom 47, and the United States the lowest scores with 42, and it is due to its subsidy for fossil fuel generation and its extraction from the global pact to fight against climate change in 2015.

Sensitivity Analysis

Equal weights have been given to different aspects of metrics to evaluate the response of evaluating sensitivity analysis to grade the energy, financial, and EPI of G7 nations. To create a composite ranking for the G7 area, a different weight system includes higher, medium, and low weights of several underlying variables. In contrast, an equal weight-based score shows the impact of outcomes by using equal weights.

One primary concern is to measure the changing practice energy, financial, and EPI of G7 nations by using equal weights to analyze underlying indicators. For the G7 countries, the uncertainty factors can be minimized to ensure the robust outcomes, as given in **Table 4**.

With instance of carbon dioxide data, the sensitivity analysis for data perturbation may potentially be verified due to the

TABLE 5 | Mean and standard deviation of sensitivity score.

Country	Std. dev	Mean
The United Kingdom	0.03	0.45
The United States	0.03	0.44
Japan	0.04	0.50
Germany	0.03	0.68
France	0.04	0.52
Italy	0.03	0.58
Canada	0.03	0.71

ambiguity inadequacy of the new consequences generated via equal weights. We do a sensitivity analysis of the G7 nations' energy, financial, and environmental presentations (see **Figure 2**). The original simulations are generated by data through the maximal multiplier, minimal multiplier, and the combination of both models into a logical combined model to eliminate the ignoring of any variable. For instance, if environmental pollution is a primary concern, the reduction of CO_2 emission remained a top priority than the reduction of energy consumption. Simultaneously, if we have an economic development as a significant development, the economic indicators remain the top priority of disproportional indicators.

Data sampling generated in the course of equal weights and the assessment of outcomes obtained through the new data set, even though it is not an objective of our study, can yield a robustness check. The performance index compares the scores of the G7 nations' energy, financial, and environmental performance.

Table 5 shows that significantly little changes in the energy economic and Environmental Performance Index and insignificant changes in the standard deviation of the mean (almost similar to actual mean) yielded insensitivity; this may be a sign of how reliable our findings are.

Discussion

During the last 4 decades, the world's economy has grown three times in size, and because of this reason, the sustainable development issue has turned into a critical discussion. The development policy of a country needs to emphasize achieving economic efficiency while improving energy efficiency and conservation. In 2018, energy utilization exceeded 157063.77 TWh worldwide. As per projections, the planet may see a 50% increase in the level of energy demand by the end of 2050, although much of it will occur in developing Asia (IEA and

BERC 2015). The energy supply distribution will be annually 0.6 percent higher in fossil fuel (0.4 percent increase in coal and an annual 1.1 percent increase in natural gas consumption). Although a sizeable proportion (3.1 percent annually) of renewable energy would also be added as renewables, production has increased from 1.06 TW to 2.18 48 TW over 9 years (2008–2017) globally (IRENA (2018). United Nations' Sustainable Development Goal #7 requires "All people must have access to cheap, dependable, safe, and contemporary energy" (World Bank 2013). Improving the energy supply chain management and incorporating renewable energy sources in this system will help achieve high energy efficiency. The application of intricate governance and technological frameworks is another way to find sustainable energy sources. However, these may not support this notion in the long run. The electricity industry, on the other hand, is expected to bring up a slew of security issues, including budgetary, tactical, technical, and environmental (Mohsin et al., 2020b; Mohsin et al., 2018; Mohsin et al., 2019; Mohsin et al., 2021).

Electric power is the most comfortable form to curtail and detoxify compared to certain other forms of energy. It portrays the most significant improvement in generating and using energy, which is also the best way to save energy worldwide. Using energy sources would most likely rely on new regulations, given strict thresholds attached to carbon dioxide emissions emitted into the atmosphere. It would raise attention to critical sources of energy with the advanced technological system. It provides some essential qualities to turn the binding energy from non-renewable carbon fuels to integrated renewables. Scale-up and investment would be required to develop new technology to meet the increased energy demand. Despite these challenges, clean energy needs funding to transfer the standardized change initiative across the steep climb to make it viable for the public. Mohsin et al. (2019), Mohsin et al. (2020a), and Mohsin et al. (2020b) have made substantial investments in creating new technological innovations to decrease their total reliance on carbon energy (Mohsin et al., 2021).

Sources of energy supply themselves have an enormous impact on energy efficiency enhancement and intensity reduction. For example, let us examine the source of the energy supply of Luxembourger. She is rushing toward renewable energy (see **Figure 3**); this is encouraging for the reduction of energy import bills, decreasing the cost of production, and improving environmental conditions. Developing Asia required this kind of energy transaction toward renewable energy as this will not help energy efficiency and intensity. However, it will improve environmental conditions and reducing the current account deficit due to low energy import bills. It will also stabilize the exchange rate due to fewer fluctuations in the demand and supply of currency, lessening the inflation rate, and, ultimately, a positive move toward sustainable development (Yang et al., 2021; He et al., 2020; Mohsin et al., 2020b). Thus, these findings are crucial for countries taking reform initiatives to maintain sustainable economic progress with better environmental conditions. Here, energy sector reforms have a dual impact on sustainable development (positive impact) and environmental degradation (negative impact) (Tiep et al., 2021). The point is important here

that power sector reforms with effective management and reforms in energy production (from non-renewable towards renewable) are key to success. This study attempted to measure some European countries' energy efficiency to picture the developing economy for their reforming policies and energy efficiency. This study has certain limitations. For example, this study investigates enough countries for a small time interval of 5-year window due to data limitation. The data set can increase to determine the big picture of this concept. The role of reform management has been decided through earlier literature on underlined countries and fluctuations in energy efficiency scores due to data limitation of such variables (Sun et al., 2019). As a result, independent research may be used to assess the degree of link among changes and their successful implementation.

The fact that increasing pollution through excessive energy consumption is caused by secondary industries explains this process (Shuai and Fan, 2020), which goes against building an improved environment (Shahbaz et al. 2018). Green: When it comes to the proportion of green zones, with statistically positive and significant coefficient values of 0.066, 0.068, and 0.056, all the estimation techniques apart from column 2 present the percentage of green zones in urban areas as being utilized for categorizing environmental guidelines. Shahbaz et al. (2018a) support the fostering of green economic growth by establishing environmental rules. The scale effect of output reflected through GDPLA at a level of 5% or above; the coefficient is scientifically positive and highly significant according to the econometric estimation, from the GDPPL perspective. Jin et al. (2018) further elaborate on land being the carrier of all living activities and human production. No financial activity can happen without land. National wealth is more likely to increase with land investment while affecting financial growth to a small extent, whereas regardless of continuous investment in technology, it is negatively impacted by land investment. In light of the results, the trade variable is insignificant in all cases. Consistency can be seen in the results of our PMG estimate and the effects mentioned before on energy emissions, which explains the theory of more substantial per capita incomes and financial efficiency created with increasing carbon emissions.

CONCLUSION AND POLICY IMPLICATION

This research created a complete and appropriate collection of indicator frameworks, which included energy financial, societal, and environmental variables linked to the energy poverty performance index (EPI). To reduce data loss during the aggregation process, the researchers developed a mathematical composite indicator. From 2001 to 2016, the G7 nations' performance was measured using the energy-economic, social, and environmental linked with energy poverty performance index (EPI). We evaluated every nation's performance based on various metrics that offer extra information in terms of relevant indicators rating prior to generating total (EPI) ratings. Many measures such as the proportion of energy self-sufficiency, energy dependence, and energy consumption per

FIGURE 2 | Sensitivity analysis overall EPI score.

FIGURE 3 | Sensitivity analysis standard deviation score.
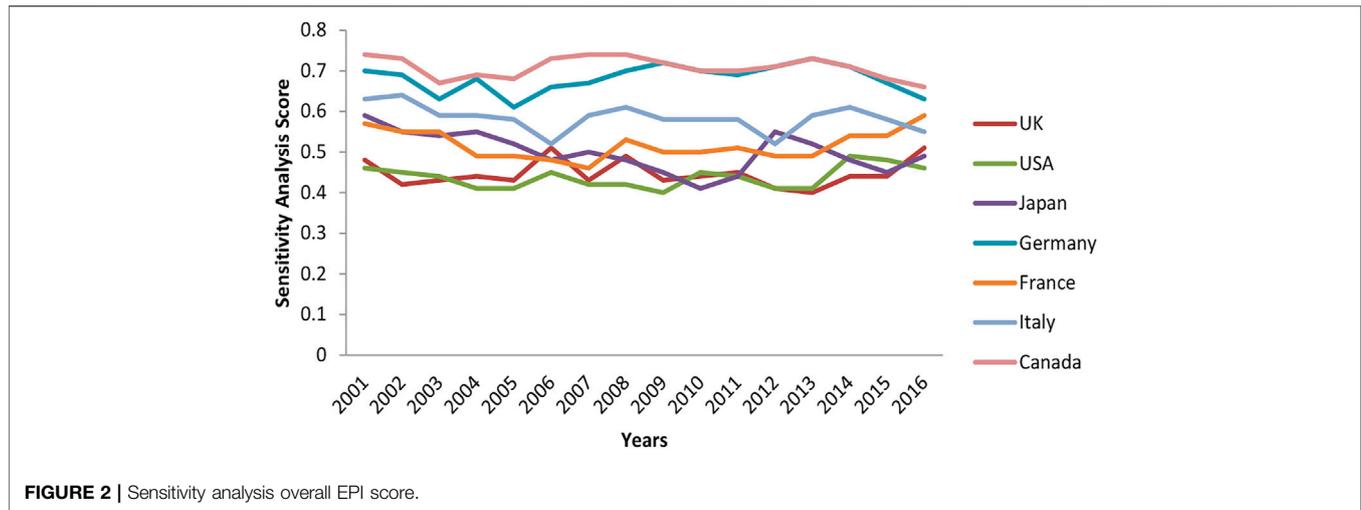
person indicate that Canada surpasses other nations. At the same moment, the United States is seen as a sensitive nation in terms of financial, political, and environmental performance in the G7. The findings suggest that Canada has the maximum EPI score, indicating that it has more capacity than the other G7 nations in terms of energy self-sufficiency, economic growth, and sustainability practices. France and Italy are ranked second and third, respectively. Japan is next with 0.50 EPI ratings, whereas the United States has the lowest average EPI, despite having the most economic development among the G7 nations. The following is the strategy that we have proposed.

There should be a strong legislative framework and initiatives in place to enhance the amount of clean, cheap energy available while maintaining a financial growth and development. At the corporate level, regulations should be adopted and environmental priorities should be prioritized, such as sidewalk consciousness. The current regime should concentrate its efforts on reducing pollution by endorsing and implementing energy efficiency policies. The administration should manage massive energy requirements

while balancing financial and environmental considerations (L. Sun et al., 2020b; H. Sun et al., 2020; L. Sun et al., 2020a). With an increase in GDP growth that results in high GHG emissions (i.e., in Canada's case, due to growth in its GDP), it is easy to see a substantial relationship between GDP growth and GHG emissions. Challenges related to energy security and more significant GHG emissions per capita are faced by other nations that utilize more energy. Emissions and energy security per capita is a significant challenge in nations, including the developed and underdeveloped countries, focusing on utilizing high energy as fossil fuel subsidies cause high GHG emissions (Petrović-Ranđelović et al., 2020). GHG emissions are most likely to be reduced emissions by the year 2030 down to 12% due to the reduction in subsidy forecasted for Australia. The significant role of fossil fuel is evident through the GHG values depicting the energy type in these nations. On the contrary, the RE utilization is high for the countries with low GHG emissions (Yoshino et al., 2020).

Energy policymakers and environmental policy analysts should globally advocate the contemporary and growing

concern of sustainable development and global warming, and there should be increasing environmental performance through benefits. Energy conservation practice should be implemented to decrease carbon-based energy consumption, while increasing demand and consumer behavior toward energy consumption should be monitored at the government level. We recommend the future study as an extension of the current study by combining the mathematical composite indicators and the Malmquist distance radial function to construct the energy poverty performance indicator with financial, societal, and environmental implications (EPI).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JH: Investigation, Data curation, Writing–original draft. HL: Formal analysis, Validation, Writing–original draft. SI: Resources, Writing–original draft. XW: Writing–review and editing.

REFERENCES

Ahmad, M., Li, H., Anser, M. K., Rehman, A., Fareed, Z., Yan, Q., et al. (2020). Are the Intensity of Energy Use, Land Agglomeration, CO2 Emissions, and Economic Progress Dynamically Interlinked across Development Levels? *Energ. Environ.* 32, 690–721. doi:10.1177/0958305X20949471

Alemzero, D. A., Iqbal, N., Iqbal, S., Mohsin, M., Chukwuma, N. J., and Shah, B. A. (2020a). Assessing the Perceived Impact of Exploration and Production of Hydrocarbons on Households Perspective of Environmental Regulation in Ghana. *Environ. Sci. Pollut. Res.* 28, 5359–5371. doi:10.1007/s11356-020-10880-3

Alemzero, D. A., Sun, H., Mohsin, M., Iqbal, N., Nadeem, M., and Vo, X. V. (2020b). Assessing Energy Security in Africa Based on Multi-Dimensional Approach of Principal Composite Analysis. *Environ. Sci. Pollut. Res.* 28, 2158–2171. doi:10.1007/s11356-020-10554-0

Al-mulali, U. (2011). Oil Consumption, CO2 Emission and Economic Growth in MENA Countries. *Energy* 36, 6165–6171. doi:10.1016/j.energy.2011.07.048

Ang, B. W., Choong, W. L., and Ng, T. S. (2015). Energy Security: Definitions, Dimensions and Indexes. *Renew. Sustain. Energ. Rev.* 42, 1077–1093. doi:10.1016/j.rser.2014.10.064

Anser, M. K., Khan, M. A., Nassani, A. A., Aldakhil, A. M., Voo, X. H., and Zaman, K. (2020d). Relationship of Environment with Technological Innovation, Carbon Pricing, Renewable Energy, and Global Food Production. *Econ. Innovation New Technol.* 1, 1–37. doi:10.1080/10438599.2020.1792607

Anser, M. K., Yousaf, Z., Majid, A., and Yasir, M. (2020f). Does Corporate Social Responsibility Commitment and Participation Predict Environmental and Social Performance? *Corp. Soc. Responsib. Environ. Manag.* 27, 2578–2587. doi:10.1002/csr.1977

APERC (2007). *Quest for Energy Security in the 21st Century: Resources and Constraints.* Tokyo, Japan: Asia Pacific Energy Res. Centre.

Apergis, N., and Payne, J. E. (2010). Renewable Energy Consumption and Economic Growth: Evidence from a Panel of OECD Countries. *Energy Policy* 38, 656–660. doi:10.1016/j.enpol.2009.09.002

Asif, M., Khan, K. B., Anser, M. K., Nassani, A. A., Abro, M. M. Q., and Zaman, K. (2020). Dynamic Interaction between Financial Development and Natural Resources: Evaluating the 'Resource Curse' Hypothesis. *Resour. Pol.* 65, 101566. doi:10.1016/j.resourpol.2019.101566

Aslan, A., Destek, M. A., and Okumus, I. (2018). Sectoral Carbon Emissions and Economic Growth in the US: Further Evidence from Rolling Window Estimation Method. *J. Clean. Prod.* 200, 402–411. doi:10.1016/j.jclepro.2018.07.237

Baloch, Z. A., Tan, Q., Iqbal, N., Mohsin, M., Abbas, Q., Iqbal, W., et al. (2020). Trilemma Assessment of Energy Intensity, Efficiency, and Environmental Index: Evidence from BRICS Countries. *Environ. Sci. Pollut. Res.* 27, 34337–34347. doi:10.1007/s11356-020-09578-3

Banker, R. D., Charnes, A., and Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Manage. Sci.* 30, 1078–1092. doi:10.1287/mnsc.30.9.1078

Banker, A. R. D., Charnes, A., Cooper, W. W., Rhodes, E., Andersen, P., Petersen, N. C., et al. (2000). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis *. *Manage. Sci.* 7, 871–885. doi:10.1016/j.ejor.2007.01.004

Boyd, G., and Färe, R. (1984). Measuring the Efficiency of Decision Making Units: A Comment. *Eur. J. Oper. Res.* 15, 331–332. doi:10.1016/0377-2217(84)90101-2

BP Statistical Review (2017). BP Statistical Review of World Energy. Br. Pet. Available at: http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf, 8–11.

Chandio, A. A., Jiang, Y., Rehman, A., Twumasi, M. A., Pathan, A. G., and Mohsin, M. (2020). Determinants of Demand for Credit by Smallholder Farmers': A Farm Level Analysis Based on Survey in Sindh, Pakistan. *J. Asian Business Econ. Stud.* 28, 225–240. ahead-of-print. doi:10.1108/jabes-01-2020-0004

Charnes, A., Cooper, W. W., and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *Eur. J. Oper. Res.* 2, 429–444. doi:10.1016/0377-2217(78)90138-8

Charnes, A., Cooper, W. W., Lewin, A. Y., and Seiford, L. M. (1994). *Data Envelopment Analysis: Theory, Methodology, and Applications.* Dordrecht: Springer. doi:10.1007/978-94-011-0637-5

Chen, Y., Wang, Z., and Zhong, Z. (2019). CO2 Emissions, Economic Growth, Renewable and Non-Renewable Energy Production and Foreign Trade in China. *Renew. Energ.* 131, 208–216. doi:10.1016/j.renene.2018.07.047

Cherchye, L., Knox Lovell, C. A., Moesen, W., and Van Puyenbroeck, T. (2007). One Market, One Number? A Composite Indicator Assessment of EU Internal Market Dynamics. *Eur. Econ. Rev.* 51, 749–779. doi:10.1016/j.euroecorev.2006.03.011

Cohen, G., Joutz, F., and Loungani, P. (2011). Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies. *Energy Policy* 39, 4860–4869. doi:10.1016/j.enpol.2011.06.034

Dı´az-Balteiro, L., and Romero, C. (2004). In Search of a Natural Systems Sustainability Index. *Ecol. Econ.* 49, 401–405. doi:10.1016/j.ecolecon.2004.02.005

Du, J., Chen, Y., and Huang, Y. (2018). A Modified Malmquist-Luenberger Productivity Index: Assessing Environmental Productivity Performance in China. *Eur. J. Oper. Res.* 269, 171–187. doi:10.1016/j.ejor.2017.01.006

Ebert, U., and Welsch, H. (2004). Meaningful Environmental Indices: A Social Choice Approach. *J. Environ. Econ. Manage.* 47, 270–283. doi:10.1016/j.jeem.2003.09.001

Esty, D. C., Levy, M., Srebotnjak, T., and de Sherbinin, A. (2005). Environmental Sustainability Index: Benchmarking National Environmental Stewardship. New Haven:Yale Center for Environmental Law and Policy. doi:10.1007/978-3-642-28036-8_116

Filipović, S., Verbič, M., and Radovanović, M. (2015). Determinants of Energy Intensity in the European Union: A Panel Data Analysis. *Energy* 92, 547–555. doi:10.1016/j.energy.2015.07.011

Fiorito, G. (2013). Can We Use the Energy Intensity Indicator to Study "Decoupling" in Modern Economies? *J. Clean. Prod.* 47, 465–473. doi:10.1016/j.jclepro.2012.12.031

Greene, D. L. (2010). Measuring Energy Security: Can the United States Achieve Oil independence? *Energy Policy* 38, 1614–1621. doi:10.1016/j.enpol.2009.01.041

He, J., Deng, J., and Su, M. (2010). CO2 Emission from China's Energy Sector and Strategy for its Control. *Energy* 35, 4494–4498. doi:10.1016/j.energy.2009.04.009

He, W., Abbas, Q., Alharthi, M., Mohsin, M., Hanif, I., Vinh Vo, X., et al. (2020). Integration of Renewable Hydrogen in Light-Duty Vehicle: Nexus between

Energy Security and Low Carbon Emission Resources. *Int. J. Hydrogen Energ.* 45, 27958–27968. doi:10.1016/j.ijhydene.2020.06.177

Hughes, L. (2009). The Four 'R's of Energy Security. *Energy Policy* 37, 2459–2461. doi:10.1016/j.enpol.2009.02.038

IEA (2017). *World Energy Statistics*. Int. Energy Agency. doi:10.1787/world_energy_stats-2017-en

Iram, R., Anser, M. K., Awan, R. U., Ali, A., Abbas, Q., and Chaudhry, I. S. (2020a). Prioritization of Renewable Solar Energy to Prevent Energy Insecurity: An Integrated Role. *Singapore Econ. Rev.* 66, 391–412. doi:10.1142/S021759082043002X

Iram, R., Zhang, J., Erdogan, S., Abbas, Q., and Mohsin, M. (2020b). Economics of Energy and Environmental Efficiency: Evidence from OECD Countries. *Environ. Sci. Pollut. Res.* 27, 3858–3870. doi:10.1007/s11356-019-07020-x

Jin, W., Zhou, C., and Luo, L. (2018). Impact of Land Input on Economic Growth at Different Stages of Development in Chinese Cities and Regions. *Sustainability* 10, 2847. doi:10.3390/SU10082847

Jun, W., Waheed, J., Hussain, H., Jamil, I., Borbášová, D., and Anser, M. K. (2020). Working Women and Per Capita Household Consumption Expenditures; an Untouched Reality. *Zb. Rad. Ekon. Fak. Rij.* 38, 35–69. doi:10.18045/zbefri.2020.1.35

Kang, S. M. (2002). A Sensitivity Analysis of the Korean Composite Environmental index. *Ecol. Econ.* 43, 159–174. doi:10.1016/s0921-8009(02)00207-0

Kemmler, A., and Spreng, D. (2007). Energy Indicators for Tracking Sustainability in Developing Countries. *Energy Policy* 35, 2466–2480. doi:10.1016/j.enpol.2006.09.006

Kong, N. Y. C., and Tongzon, J. (2006). Estimating Total Factor Productivity Growth in Singapore at Sectoral Level Using Data Envelopment Analysis. *Appl. Econ.* 38, 2299–2314. doi:10.1080/00036840500427544

Konstantinaviciute, I., and Bobinaite, V. (2015). Comparative Analysis of Carbon Dioxide Emission Factors for Energy Industries in European Union Countries. *Renew. Sustain. Energy. Rev.* 51, 603–612. doi:10.1016/j.rser.2015.06.058

Lambiri, D., Biagi, B., and Royuela, V. (2007). Quality of Life in the Economic and Urban Economic Literature. *Soc. Indic. Res.* 84, 1–25. doi:10.1007/s11205-006-9071-5

Laponche, B., and Tillerson, K. (2001). Documentation. *Comp. Strategy* 20, 425–432. doi:10.1080/713839468

Lin, K, Peng, M. Y. P., Anser, M. K., Yousaf, Z., and Sharif, A. (2020). Bright harmony of Environmental Management Initiatives for Achieving Corporate Social Responsibility Authenticity and Legitimacy: Glimpse of Hotel and Tourism Industry. *Corp. Soc. Responsib. Environ. Manag.* 28, 640–647. doi:10.1002/csr.2076

Liu, X., Peng, M. Y.-P., Anser, M. K., Chong, W.-L., and Lin, B. (2020). Key Teacher Attitudes for Sustainable Development of Student Employability by Social Cognitive Career Theory: The Mediating Roles of Self-Efficacy and Problem-Based Learning. *Front. Psychol.* 11, 1945. doi:10.3389/fpsyg.2020.01945

Löschel, A., Moslener, U., and Rübbelke, D. T. G. (2010). Indicators of Energy Security in Industrialised Countries. *Energy Policy* 38, 1665–1671. doi:10.1016/j.enpol.2009.03.061

Lombardi, P., and Schwabe, F. (2017). Sharing Economy as a New Business Model for Energy Storage Systems. *Appl. Energy.* 188, 485–496. doi:10.1016/j.apenergy.2016.12.016

Lund, H., and Mathiesen, B. V. (2009). Energy System Analysis of 100% Renewable Energy Systems-The Case of Denmark in Years 2030 and 2050. *Energy* 34, 524–531. doi:10.1016/j.energy.2008.04.003

Martínez, D. M., and Ebenhack, B. W. (2008). Understanding the Role of Energy Consumption in Human Development through the Use of Saturation Phenomena. *Energy Policy* 36, 1430–1435. doi:10.1016/j.enpol.2007.12.016

Mohsin, M., Zhou, P., Iqbal, N., and Shah, S. A. A. (2018). Assessing Oil Supply Security of South Asia. *Energy* 155, 438–447. doi:10.1016/J.ENERGY.2018.04.116

Mohsin, M., Rasheed, A. K., Sun, H., Zhang, J., Iram, R., Iqbal, N., et al. (2019). Developing Low Carbon Economies: An Aggregated Composite index Based on Carbon Emissions. *Sustainable Energ. Tech. Assessments* 35, 365–374. doi:10.1016/j.seta.2019.08.003

Mohsin, M., Nurunnabi, M., Zhang, J., Sun, H., Iqbal, N., Iram, R., et al. (2020a). The Evaluation of Efficiency and Value Addition of IFRS Endorsement towards Earnings Timeliness Disclosure. *Int. J. Fin Econ.* 26, 1793–1807. doi:10.1002/ijfe.1878

Mohsin, M., Taghizadeh-Hesary, F., Panthamit, N., Anwar, S., Abbas, Q., and Vo, X. V. (2020b). Developing Low Carbon Finance Index: Evidence from

Developed and Developing Economies. *Finance Res. Lett.*, 101520. doi:10.1016/j.frl.2020.101520

Mohsin, M., Hanif, I., Taghizadeh-Hesary, F., Abbas, Q., and Iqbal, W. (2021). Nexus between Energy Efficiency and Electricity Reforms: A DEA-Based Way Forward for Clean Power Development. *Energy Policy* 149, 112052. doi:10.1016/j.enpol.2020.112052

Muneer, M. A., Asif, M., and Muneer, T. (2007). Energy Supply, its Demand and Security Issues for Developed and Emerging Economies. *Renew. Sustain. Energ. Rev.* 11, 1388–1413. doi:10.1016/j.rser.2005.05.001

Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., and Giovannini, E. (2005). *Handbook on Constructing Composite Indicators*. OECD Statistics Working Papers. doi:10.1787/533411815016

Pasqualetti, M. J., and Sovacool, B. K. (2012). The Importance of Scale to Energy Security. *J. Integr. Environ. Sci.* 9, 167–180. doi:10.1080/1943815X.2012.691520

Patlitzianas, K. D., Doukas, H., Kagiannas, A. G., and Psarras, J. (2008). Sustainable Energy Policy Indicators: Review and Recommendations. *Renew. Energ.* 33, 966–973. doi:10.1016/j.renene.2007.05.003

Petrović-Ranđelović, M., Mitić, P., Zdravković, A., Cvetanović, D., and Cvetanović, S. (2020). Economic Growth and Carbon Emissions: Evidence from CIVETS Countries. *Appl. Econ.* 52, 1806–1815. doi:10.1080/00036846.2019.1679343

Radovanović, M., and Filipović, S. (2015). New Approach to Energy Intensity in the EU–Total Energy and Carbon Cost Approach. *Energy Environ* 26, 601–616. doi:10.1260/0958-305X.26.4.601

Radovanović, M., Filipović, S., and Pavlović, D. (2017). Energy Security Measurement – A Sustainable Approach. *Renew. Sustain. Energ. Rev.* 68, 1020–1032. doi:10.1016/j.rser.2016.02.010

Sarker, S. A., Wang, S., Adnan, K. M. M., Anser, M. K., Ayoub, Z., Ho, T. H., et al. (2020). Economic Viability and Socio-Environmental Impacts of Solar home Systems for Off-Grid Rural Electrification in Bangladesh. *Energies* 13, 679. doi:10.3390/en13030679

Scarlat, N., Dallemand, J.-F., Monforti-Ferrario, F., Banja, M., and Motola, V. (2015). Renewable Energy Policy Framework and Bioenergy Contribution in the European Union - an Overview from National Renewable Energy Action Plans and Progress Reports. *Renew. Sustain. Energ. Rev.* 51, 969–985. doi:10.1016/j.rser.2015.06.062

Shahbaz, M., Lahiani, A., Abosedra, S., and Hammoudeh, S. (2018). The Role of Globalization in Energy Consumption: A Quantile Cointegrating Regression Approach. *Energ. Econ.* 71, 161–170. doi:10.1016/j.eneco.2018.02.009

Shannon, C. E. (1948). A Mathematical Theory of Communication. *Bell Syst. Tech. J.* 27, 379–423. doi:10.1002/j.1538-7305.1948.tb01338.x

Shephard, R. W. (1978). "A Dynamic Formulation of Index Functions for the Theory of Cost and Production," in *Theory and Applications of Economic Indices* (Heidelberg: Physica), 417–448. doi:10.1007/978-3-662-41486-6_20

Shuai, S., and Fan, Z. (2020). Modeling the Role of Environmental Regulations in Regional green Economy Efficiency of China: Empirical Evidence from Super Efficiency DEA-Tobit Model. *J. Environ. Manage.* 261, 110227. doi:10.1016/j.jenvman.2020.110227

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Rev. Econ. Stat.* 39, 312. doi:10.2307/1926047

Sovacool, B. K., and Mukherjee, I. (2011). Conceptualizing and Measuring Energy Security: A Synthesized Approach. *Energy* 36, 5343–5355. doi:10.1016/j.energy.2011.06.043

Sun, H.-p., Tariq, G., Haris, M., and Mohsin, M. (2019). Evaluating the Environmental Effects of Economic Openness: Evidence from SAARC Countries. *Environ. Sci. Pollut. Res.* 26, 24542–24551. doi:10.1007/s11356-019-05750-6

Sun, H., Pofoura, A. K., Adjei Mensah, I., Li, L., and Mohsin, M. (2020). The Role of Environmental Entrepreneurship for Sustainable Development: Evidence from 35 Countries in Sub-Saharan Africa. *Sci. Total Environ.* 741, 140132. doi:10.1016/j.scitotenv.2020.140132

Sun, L., Cao, X., Alharthi, M., Zhang, J., Taghizadeh-Hesary, F., and Mohsin, M. (2020a). Carbon Emission Transfer Strategies in Supply Chain with Lag Time of Emission Reduction Technologies and Low-Carbon Preference of Consumers. *J. Clean. Prod.* 264, 121664. doi:10.1016/j.jclepro.2020.121664

Sun, L., Qin, L., Taghizadeh-Hesary, F., Zhang, J., Mohsin, M., and Chaudhry, I. S. (2020b). Analyzing Carbon Emission Transfer Network Structure Among Provinces in China: New Evidence from Social Network Analysis. *Environ. Sci. Pollut. Res.* 27, 23281–23300. doi:10.1007/s11356-020-08911-0

Tapia, J. F. D., Lee, J.-Y., Ooi, R. E. H., Foo, D. C. Y., and Tan, R. R. (2016). Optimal CO2 Allocation and Scheduling in Enhanced Oil Recovery (EOR) Operations. *Appl. Energ.* 184, 337–345. doi:10.1016/j.apenergy.2016.09.093

Tehreem, H. S., Anser, M. K., Nassani, A. A., Abro, M. M. Q., and Zaman, K. (2020). Impact of Average Temperature, Energy Demand, Sectoral Value Added, and Population Growth on Water Resource Quality and Mortality Rate: it Is Time to Stop Waiting Around. *Environ. Sci. Pollut. Res.* 27, 37626–37644. doi:10.1007/s11356-020-09822-w

The World Bank Data (2018). *New Country Classifications by Income Level: 2017-2018 [WWW Document]*. World Bank Gr.

Tiep, N. C., Wang, M., Mohsin, M., Kamran, H. W., and Yazdi, F. A. (2021). An Assessment of Power Sector Reforms and Utility Performance to Strengthen Consumer Self-Confidence towards Private Investment. *Econ. Anal. Pol.* 69, 676–689. doi:10.1016/j.eap.2021.01.005

Turton, H., and Barreto, L. (2006). Long-term Security of Energy Supply and Climate Change. *Energy Policy* 34, 2232–2250. doi:10.1016/j.enpol.2005.03.016

US Energy Information Administration (2017). International Energy Outlook 2017 Overview. Available at: www.eia.gov/forecasts/ieo/pdf/0484(2016).pdf, 143

Vera, I., and Langlois, L. (2007). Energy Indicators for Sustainable Development. *Energy* 32, 875–882. doi:10.1016/j.energy.2006.08.006

Verbruggen, A. (2008). Renewable and Nuclear Power: A Common Future? *Energy Policy* 36, 4036–4047. doi:10.1016/j.enpol.2008.06.024

Wang, H., Chen, W., and Shi, J. (2018a). Low Carbon Transition of Global Building Sector under 2- and 1.5-Degree Targets. *Appl. Energ.* 222, 148–157. doi:10.1016/j.apenergy.2018.03.090

Wang, X., van't Veld, K., Marcy, P., Huzurbazar, S., and Alvarado, V. (2018b). Economic Co-optimization of Oil Recovery and CO2 Sequestration. *Appl. Energ.* 222, 132–147. doi:10.1016/j.apenergy.2018.03.166

Wang, X. (2011). On China's Energy Intensity Statistics: Toward a Comprehensive and Transparent Indicator. *Energy Policy* 39, 7284–7289. doi:10.1016/j.enpol.2011.08.050

Wasif Rasheed, H. M., and Anser, M. K. (2017). Effect on Brand Loyalty in Mobile Phone Purchasing (A Case Study in Bahawalpur, Pakistan). *J. Public Adm. Governance* 7, 47–60. doi:10.5296/jpag.v7i1.11042

Wolde-Rufael, Y., and Menyah, K. (2010). Nuclear Energy Consumption and Economic Growth in Nine Developed Countries. *Energ. Econ.* 32, 550–556. doi:10.1016/j.eneco.2010.01.004

World Bank Data Base (2018). GDP Per Capita (Current US$) | Data [WWW Document]. OECD Natl. Accounts data files

World Bank (2015). *World Development Report*. 日経ビジネス. doi:10.1596/978-1-4648-0342-0

World Energy Council and Oliver Wyman (2018). *World Energy Trilemma Index 2018.* [WWW Document]. World Energy Counc.

Xu, Y., Chen, Z., Peng, M. Y.-P., and Anser, M. K. (2020). Enhancing Consumer Online Purchase Intention Through Gamification in China: Perspective of Cognitive Evaluation Theory. *Front. Psychol.* 11, 581200. doi:10.3389/fpsyg.2020.581200

Yang, Z., Abbas, Q., Hanif, I., Alharthi, M., Taghizadeh-Hesary, F., Aziz, B., et al. (2021). Short- and Long-Run Influence of Energy Utilization and Economic Growth on Carbon Discharge in Emerging SREB Economies. *Renew. Energ.* 165, 43–51. doi:10.1016/j.renene.2020.10.141

Yao, L., and Chang, Y. (2014). Energy Security in China: A Quantitative Analysis and Policy Implications. *Energy Policy* 67, 595–604. doi:10.1016/j.enpol.2013.12.047

Yoshino, N., Taghizadeh-Hesary, F., and Otsuka, M. (2021). Covid-19 and Optimal Portfolio Selection for Investment in Sustainable Development Goals. *Finance Res. Lett.* 38, 101695. doi:10.1016/j.frl.2020.101695

Yousaf, S., Anser, M. K., Tariq, M., Sahibzada Jawad, S. U. R., Naushad, S., and Yousaf, Z. (2020). Does Technology Orientation Predict Firm Performance through Firm Innovativeness? *World J. Entrep. Manag. Sustain. Dev.* 17, 140–151. doi:10.1108/WJEMSD-11-2019-0091

Yuan, J.-H., Kang, J.-G., Zhao, C.-H., and Hu, Z.-G. (2008). Energy Consumption and Economic Growth: Evidence from China at Both Aggregated and Disaggregated Levels. *Energ. Econ.* 30, 3077–3094. doi:10.1016/j.eneco.2008.03.007

Zhe, L., Yong, G., Hung-Suck, P., Huijuan, D., Liang, D., and Tsuyoshi, F. (2016). An Emergy-Based Hybrid Method for Assessing Industrial Symbiosis of an Industrial Park. *J. Clean. Prod.* 114, 132–140. doi:10.1016/j.jclepro.2015.04.132

Zhou, P., and Ang, B. W. (2008). "Indicators for Assessing Sustainability Performance," in *Handbook of Performability Engineering* (London: Springer), 905–918.

Zhou, P., and Ang, B. W. (2009). Comparing MCDA Aggregation Methods in Constructing Composite Indicators Using the Shannon-Spearman Measure. *Soc. Indic. Res.* 94, 83–96. doi:10.1007/s11205-008-9338-0

Zhou, P., Ang, B. W., and Poh, K. L. (2006). Comparing Aggregating Methods for Constructing the Composite Environmental Index: An Objective Measure. *Ecol. Econ.* 59, 305–311. doi:10.1016/J.ECOLECON.2005.10.018

Zhou, P., Ang, B. W., and Zhou, D. Q. (2010). Weighting and Aggregation in Composite Indicator Construction: A Multiplicative Optimization Approach. *Soc. Indic. Res.* 96, 169–181. doi:10.1007/s11205-009-9472-3