

Article

Carbon-Free Energy and Sustainable Environment: The Role of Human Capital and Technological Revolutions in Attaining SDGs

Hebin Shen ¹, Syed Ahtsham Ali ^{2,*}, Majed Alharthi ³ , Ali Shan Shah ⁴, Abdul Basit Khan ⁴, Qaiser Abbas ⁵ and Saeed ur Rahman ⁵

¹ School of International Business, Southwestern University of Finance and Economics, Chengdu 611130, China; shenhebin170@outlook.com

² Business School, Shanghai Jian Qiao University, Shanghai 201306, China

³ Finance Department, College of Business, King Abdulaziz University, P.O. BOX. 344, Rabigh 21911, Saudi Arabia; mdalharthi@kau.edu.sa

⁴ Department of Political Science & IR, Government College University Faisalabad, Punjab 38000, Pakistan; Alishanshah@gcuf.edu.pk (A.S.S.); abdulbasit@gcuf.edu.pk (A.B.K.)

⁵ Department of Economics, Ghazi University, DG. Khan, Punjab 38000, Pakistan; Qabbas@gudgk.edu.pk (Q.A.); srehan@gudgk.edu.pk (S.u.R.)

* Correspondence: brillpak@yahoo.com



Citation: Shen, H.; Ali, S.A.; Alharthi, M.; Shah, A.S.; Basit Khan, A.; Abbas, Q.; ur Rahman, S. Carbon-Free Energy and Sustainable Environment: The Role of Human Capital and Technological Revolutions in Attaining SDGs. *Sustainability* **2021**, *13*, 2636. <https://doi.org/10.3390/su13052636>

Received: 5 January 2021

Accepted: 15 February 2021

Published: 1 March 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: During the time before the Millennium Development Goals (MDGs) are achieved, the international community has set goals to improve people's lives worldwide. This is in line with the United Nations' 2030 ambitions to strengthen and advance human society's sustainable development. Goal number 7 (Affordable and Clean Energy), goal number 9 (Industry, Innovation, and Infrastructure), and goal number 13 (Climate Action) are highly correlated to each other. The current study investigates the role of human capital and technological innovation in achieving sustainable development goals (SDGs) through a carbon-free energy system. A 19-year dataset covering the years 2000–2018 for the G7 economies has been utilized by using the composite index, Multi-criteria decision analysis, and Quantile Autoregressive Distributed Lag (QARDL) methods. The study's outcomes indicate that the human capital index and technological innovations contribute positively to SDGs in G7 economies. Both indicators also contribute positively to the carbon-free economy by contributing to carbon-free energy sources. The financial index and energy index results also indicate a positive association with the carbon-free economy in G7 nations. This study suggests policy guidelines for developed as well as for developing economies based on human capital and technological innovation to fulfill the SDGs.

Keywords: carbon-free energy; human capital; technological revolutions; sustainable development goals; QARDL; composite index

1. Introduction

Global warming has intensified by almost 50% over the last 20 years owing to greenhouse gas pollution [1]. Climate change is intensifying and is affecting millions of individuals' lives by triggering the destructive nature of hurricanes, forest fires, and floods, which are becoming more significant and occurring more frequently over time. It means we need to be organized and capable enough to cope with the effects of climate change and manage its repercussions. It will be necessary even if we can control global warming at a 2 °C increase, as expected by the Paris Agreement. According to the United Nations (UN) estimates, the world population is anticipated to reach 8.5 billion by the end of 2030 [2]. The rising pace of urbanization is another significant environmental threat globally, as the world's urbanized population will reach about 5 billion individuals by 2030 [3]. The towns of the future must be greener, fitter, and more sustainably managed. The World Health

Organization (WHO) claims that more than 90% of humankind is breathing toxic air. If we do not reduce air pollution to reduce respiratory disease rates, then 7 million more people will die each year [4]. Polluted water causes 5 million deaths annually and contributes to massive health risks. The UN continues to campaign to reduce the use of chemicals and minimize raw sewage volume discharges into rivers and seas. Various species threatened by extinction have lost an estimated 8% of their habitat in the last 25 years [5]. Furthermore, an additional 22% of species worldwide are at risk of facing extinction due to poaching, introducing invasive species, and climate change. The UN has recommended substantial measures for the protection of natural resources and maintenance of our ecosystem.

Under the previous paradigm of human economics, when the human economic subsystem was limited, the “restorative and assimilationist capabilities of the ecosystem were considered to be infinite”. Now, we realize that natural resources are not limitless. As a result, the sustainable use of resources is much more critical than ever. The human economy’s capability was influential in the past, but its productivity and impacts have become too large for the natural environment, and natural resources such as oil and land have now become much more limited.

The earliest definition of sustainability defines it as “development that satisfies present demands, while at the same time fulfilling future demands”. Since then, three meanings of the sustainable development concept have been developed, and achieving all three sustainable development concepts requires economic, environmental, and social sustainability. Environmental sustainability refers to the environment’s capacity to continue with its current environmental quality level (without degradation) with a low level of exploitation of natural resources forever. Economic sustainability allows an economy to maintain the same economic production levels in the long run. Social sustainability is the capacity of a community, such as a government, family, or organization, to operate at a sustainable social well-being level for an indefinite period.

Too much economic development has contributed to an environmental and social catastrophe. Global economic growth is speeding beyond the limits of natural resources globally and is becoming one of the leading global challenges that we need to address. For this purpose, we need to engage in more realistic approaches for both the environment and individuals. Building in a way that would achieve the sustainable development goals (SDGs) using current investment methods is impractical because these methods are not conducive for the achievement of the SDGs, and because we are currently on the verge of a climate crisis. We face a \$2.5 trillion global fund deficit, which is particularly acute for developing nations [6]. It would undoubtedly be challenging to achieve the sustainable development goals (SDGs) by 2030 if we were to stick with the current trends. It would have negative consequences for all persons, organizations, and countries.

There are some new approaches under consideration to help achieve the SDGs. Strong leadership is the key to meeting sustainable development goals; thus, investing in human capital is the most effective way to achieve those goals. The World Economic Forum, World Bank, UN Foundation, Skoll Foundation, and the Bill & Melinda Gates Foundation are major backers of human capital in addition to financial capital. According to the “Human Capital Report”, knowledge and skill are arguably the most important factors [7]. The United Nations General Assembly (UNGA) recognizes that public–private collaborations have a major role in achieving the SDGs’ human capital goals. The UNGA has noted that increasing citizens’ active engagement is one way to fulfill the SDGs’ strategy of ensuring “no one left behind.” In this way, everybody throughout the world will become agents of their destiny. The environmental divide between towns and gowns needs to be crossed immediately.

Human capital investment is essential but does not guarantee sustainable growth without human progress. Thus, human capital growth is more significant for the sustainable growth of the economy. Sustainable economic growth can be encouraged if investments in health, education, skills, employment opportunities, and childhood development are

augmented. Governments that invest in human resources are becoming a significant contributor to boosting and developing societies, markets, and economies worldwide.

The latest ecological breakthrough aims to combat modern countries' environmental issues in moving towards a greener and low-carbon climate. It is referred to as "green" or "clean" technology as it seeks to preserve, track, or reduce the harmful effect of technology on the environment and the use of resources. Technology that does not harm the environment and natural resources is crucial in preserving and improving life quality. The use of technology cannot accomplish sustainable development, but its wise application may help protect the environment. Scientists would be persuaded that environmentally friendly technological advances are the only way to save our world. Historically, new technologies have been developed in response to demographic and economic challenges and demands.

According to the United Nations, over 60% of GHG emissions are released by oil. In comparison, 13% of the world's population lacks electricity provision because more than 3 billion people rely on fossil fuels for cooking and heat [8]. This situation calls for energy transformation to a greener type to help inclusive societies that are more prosperous, sustainable, and immune to environmental harm, including climate change. Scientists have proposed the use of so-called green technologies to combat global warming. Scientists are working to create innovations aimed at mitigating global warming and climate change worldwide. There are several options to cope with energy scarcity in the future. Green development is distinct from sustainable development as it focuses on environmental protection over economic and cultural factors. Advocates of sustainable development contend that green development technology is non-existent; instead, it can only be developed and studied. Sustainable development will happen with the help of green growth. Sustainability relies on the development of technology that may prove helpful in reducing carbon emissions.

The study thus looks at the role of human capital, cleaner technology development, and some other economic determinants to achieve the optimal conditions for the participating sectors. To this end, the energy index, financial index, human index, and environmental index of critical economic factors have been established for G7 countries. We use a recently invented Quantile Autoregressive Distributed Lag (QARDL) and a composite index model to analyze human capital and renewable technological innovation effect on environmental and other metrics for 2000–2018.

The remainder of the study contains the following parts. The following segment includes a short overview of the literature. The analysis methodology is illustrated in Section 2. The findings are discussed in Section 3, and in Section 4 the results are addressed, and policy consequences are discussed.

Literature Review

In modern times, the field of the subject under debate has been taken up by researchers. In this fast-paced developing world, there are imminent projects that need human investment, and any such undertaking must go hand in hand with challenging investment projects. The economic justification for building human capital is evident [9]. These are the issues required to be solved for the better quality of life, improved health, reduced population growth, reduced stunting rates, increased quality of education, and creation of more youth employment. In an atmosphere of rapid growth and development, quality human capital development is a requirement that must be given special attention. Even though the return on investment is difficult to quantify, human capital investment more significantly brings about worldwide economic growth. Rapid human capital productivity enables a country to implement new technologies [10] rapidly. Human capital encompasses all schooling stages, including technological and administrative expertise in human and organizational growth related to global competitiveness. Human capital development plays a key role in designing sound policies and building productive institutions and organizations [11]. Human capital development enables individuals to have a comparative

advantage over others. Human capital consists of health, education, expertise, experience, leadership, and access to services [12].

Innovation has played a significant role in economic growth throughout history. The income per capita is influenced by technical and innovation shifts [13]. For long-term sustainability, the use of the latest techniques may reap enormous benefits. Technology and innovation policy should address the concerns of the overall Sustainable Development Goals set by the United Nations [14]. New technologies and innovative systems should be developed and introduced to reduce the divide between developed and developing nations [15]. In either case, certain technologies—including those that may have tremendous potential benefits—may entail inevitable trade-offs that need to be defined, analyzed, and taken care of [16].

Sustainability can be achieved through the advancement in energy technologies [17]. It is inevitable to have industrial dependency because of the use of fossil fuels. It will only be sustainable if the world reduces the use of fossil fuels. Technical initiatives should aim to increase the reliability of energy supply and energy usage and transition to oil and coal technology more soundly concerning the environment. Natural gas is readily available and can play a crucial role in developing the environment in a way that is less dependent on fossil fuels. Renewable energy technologies are being extinguished faster than ever before and are now readily accessible to more people [18]. It will most likely be conducive to health and education to “upgrade” growth.

Environmental innovations work towards the promotion of energy use efficiency in industrial sectors [19]. Businesses need to influence green technologies to ensure eco-friendly and sustainable government policies and management [20]. We first need to develop an indigenous technical capability by involving the professional and knowledgeable technologists, scholars, and staff in process of environmental innovations [21].

The challenge is clear: to solve the investment gap in Sustainable Development Goals, a flow of “efficient” financial instruments and solutions is required. Investors and business owners need to understand the value of these evolving frontier markets and recognize their challenges for doing business there. These markets may also be regarded as a catalyst for essential portions of the sustainable development goals (SDGs). The present need is for the government to implement this urgent development strategy. Development agencies, multilateral funding institutions, regulatory bodies, and the private business sector are ready to support this proposal fully. They must be pioneers in finding a greener world in the future. There are also inherent problems in the process of sustainable investment, including misaligned incentives and legislation and concerns with professionally evaluating sustainable investments. It is counterproductive in formulating a long-term approach toward sustainable investment. This study aims to bridge the gap in sustainable financial, human resources, and technical advancement to achieve sustainable development goals. The role of human capital in technical innovation, economic growth, and investment cannot be ignored in the developed economies to resolve the crisis emerging from renewable carbon-free energy sources and practical initiatives for an effective environmental friendly technology.

2. Data and Methodology

Panel dataset of nineteen years (2000–2018) consisting of eleven different indicators of group of 7 (G-7) economies were been collected from World Development Indicators (WDI). These indicators have been listed in four different indexes. Air and greenhouse gas emission (Tonne_cap) and air pollution (Harmful algal blooms) (10 million Harmful algal blooms have been formed as an environmental index (ENI), while renewable energy (Tonne of oil equivalent (KTOE) and R&D (percentage of Gross Domestic Product) in renewable energy have been included in the energy index (EI). The human capital index (HCI) has been formed with education cost (percentage of GDP), health cost (percentage of GDP per capita), and labor cost (percentage of GDP). Finally, the financial index (FI) has

been developed with foreign direct investment index (USD), exports (percentage of GDP), consumer price index (percentage of CPI), and GDP (current USD).

2.1. Model Specification

2.1.1. Operation Research Modeling

Multi-Criteria Decision Analysis (MCDA) is commonly used to achieve the composite index by the underlying measures. The Data Envelopment Analysis (DEA) model is used for evaluating the broad consequences for economic and environmental protection, such that “m” is the total number of entities in the job division and “n” denotes the number of sub-indicators [22]:

$$\begin{aligned} bI_i &= \min \sum_{j=1}^n W_{ij}^g I_{ij} \\ \text{s.t. } bI_i &= \min \sum_{j=1}^n W_{ij}^b I_{kj} \leq 1, \quad k = 1, 2, \dots, m \\ W_{ij}^b &\geq 0, \quad j = 1, 2, \dots, n \end{aligned} \quad (1)$$

With Equation’s aid (1), the model assesses enterprises’ qualities by indicator entity i. Equation (1) has the same objective function and uses the same optimization approach as the Simple Additive Weighted (SAW) method. [23]. Each entity will accumulate one score. Since the “alternative agent” is a dominating “indicator”, other indicators’ values are incorrect. Another way to address this issue is to extend the current DEA model in the service of Equation (1) as follows:

$$\begin{aligned} gI_i &= \min \sum_{j=1}^n W_{ij}^g I_{ij} \\ \text{s.t. } gI_i &= \min \sum_{j=1}^n W_{ij}^g I_{ij} \leq 1, \quad k = 1, 2, \dots, m \\ W_{ij}^g &\geq 0, \quad j = 1, 2, \dots, n \end{aligned} \quad (2)$$

To sum the sub-indicators, Equation (2) uses the outcome of the “worse set of weights” to measure each object’s efficiency score. Equation (2) is closely related to the duplex-determinist method with steady-state production [24,25]. Both these models use the DEA model to determine the efficiency of each entity. These indexes compute the partial scores of components based on their various characteristics. Finally, the CI index is constructed as follows:

$$(CI)\lambda = \lambda \frac{gI_i - gI^-}{gI^* - gI^-} + (1 - \lambda) \frac{bI_i - bI^-}{bI^* - bI^-}$$

Where $gI^* = \max \{ gI_i, i = 1, 2, 3, \dots, m \}$, $gI^- = \min \{ gI_i, i = 1, 2, 3, \dots, m \}$ (3)
And $bI^* = \max \{ bI_i, i = 1, 2, 3, \dots, m \}$, $bI^- = \min \{ bI_i, i = 1, 2, 3, \dots, m \}$

In Equation (3), λ is modeled with linear scaling only between the lowest and the highest. It only adds up all the sub-indicators and measure the total. λ can vary from 0.5 to 1, with a normalized version being $g-i$. While $\lambda = 1$, its normalized version is $-i$, and this is a negotiation among preferences when $\lambda = 0$. This model is not feasible owing to unrealistic results. In this model, no restrictions have been imposed on the selection of weightage for the respective variables.

This problem has been eliminated when combined with the universal weight-integral spirit model. To calculate entity i’s deviation from the expected value, d_i can be used. By solving the problem “m” times, it can minimize the efficiency of a single entity:

$$\begin{aligned} \varphi &= m \text{ i n } d_i \\ gI_i &= M - d_i + \left(\sqrt{S^+ + s^-} \right) \\ \text{s.t. } \sum_{i=1}^n W_{ij} I_{kj} - d_k + \left(\sqrt{S^+ + s^-} = 1 \right) &= 1, \quad k = 1, 2, 3, \dots, m \\ W_{ij} &\geq 0, \quad j = 1, 2, 3, \dots, n, \quad k = 1, 2, 3, \dots, m \end{aligned} \quad (4)$$

Equation (4) picks the best method for weighting each attribute. Moreover, one suggestion to solve this model would be to add a sub-indicator for each factor. We introduced two slacks variable $(\sqrt{S^+ + s^-})$ to minimize misutilization of any entities. For “ i ”, the required weight set is determined according to Equation (4). To make maximum efficiencies from Equation (4), a deviation of that ‘ T ’ in the objective function is necessary. The minimax value strategy implies this. Thus, the MCDA-DEA model looks like this:

$$\begin{aligned} \theta &= \max M \\ bI_i &= M - d_i (\sqrt{S^+ + s^-} = 1) \geq 0 \\ \text{s.t. } \sum_{i=1}^n W_{ij} I_{kj} - d_k + \left((\sqrt{S^+ + s^-} = 1) \right) & \quad k = 1, 2, 3, \dots, m \\ W_{ij} &\geq 0, d_i \geq 0, j = 1, 2, 3, \dots, n \quad i = 1, 2, 3, \dots, m \end{aligned} \quad (5)$$

where $W-i$. represents the common proportion between all indicators i that characterizes all possible occurrences, particularly, $M - d_i \geq 0$ to entirely confirm “ i ”; $M = \max \{d_i, i = 1, 2, 3, \dots, m\}$ is also applied by [24] as an appropriate choice. The lowest common denominator to this partner’s bond has been verified as the highest weight commensurable for the positive everyday use. The significance of any sub-indicator e.g., ($\varepsilon \approx 0$) underlined by [26,27], suggests a higher ε value compared to smaller ε value to tackle increasing discriminatory issues between the underlying entities, while the small value is not a severe issue. Thus, we can restructure the Equation (5) as follows:

$$LCI = \varphi \times \theta \quad (6)$$

In Equation (6), $\forall i = 1, 2, \dots, m$, $CI_i = 1 - d_i$. An individual’s score with a high contribution to the other sub-indicators is given even if its value is incorrect. MCDA would be included in the committee discussions to minimize the total uncertainty. According to a set of entities “LCI” that is shown in the current analytical structure of CEI, another parameter “K” should be modified to [0,1].

2.1.2. Econometric Modeling

Quantile Autoregressive Distributive Lag (QARDL)

The present study used the QARDL model proposed by [28] to test the long-run relationship’s stability. For this purpose, developing the quantiles and inferring a flexible econometric framework to depict the relationship among human capital, technological innovation, energy, and environmental pollution in the economies is under consideration. The use of QARDL is beneficial as compared to the linear ARDL because the QARDL model can introduce possible asymmetries in the reaction of human capital formation and utilization of types of energy to promote or reduce environmental pollution in different times segments.

Note that the ARDL process is defined as $Y_t = \alpha_* + \sum_{j=1}^p \phi_{j*} Y_{t-j} + \sum_{j=0}^q \theta_{j*} X_{t-j} + U_t$, where $X_t \in \mathbb{R}^k$ is a stationary and ergodic process integrated with population average zero, U_t is the error term that is defined as $Y_t - \mathbb{E}[Y_t | \mathcal{F}_{t-1}]$ with $\mathcal{F}_{t-1}$ being the smallest σ -field generated by $\{X'_t, Y_{t-1}, X'_{t-1}, \dots\}$, and p and q are lag orders. We also consider that the k variables in X_t are not synchronized with each other. Following this framework, we let the τ -th quantile of Y_t conditional on $\mathcal{F}_{t-1}$ be given as $\alpha_*(\tau) + \sum_{j=1}^p \phi_{j*}(\tau) Y_{t-j} + \sum_{j=0}^q \theta'_{j*}(\tau) X_{t-j}$ and denote this as $Q_{Y_t}(\tau/Y_{t-j})$. Y_t can be represented as

$$Y_t = \alpha_*(\tau) + \sum_{j=1}^p \phi_{j*}(\tau) Y_{t-j} + \sum_{j=0}^q \theta'_{j*}(\tau) X_{t-j} + U_t(\tau) \quad (7)$$

This is called the QARDL method. Here, $U_t(\tau)$ is defined as $Y_t - Q_{Y_t}(\tau/Y_{t-j})$, as in [29].

We reformulate (7) to evaluate the QARDL mechanism:

$$Y_t = \alpha_*(\tau) + \sum_{j=0}^{q-1} W'_{t-j} \delta_{j*}(\tau) X'_t \gamma_*(\tau) + \sum_{j=1}^p \varnothing_{j*}(\tau) Y_{t-j} + U_t(\tau), \quad (8)$$

where $\gamma_*(\tau) = \sum_{j=0}^q \theta_{j*}(\tau)$, $W_t = \Delta X_t$, and $\delta_{j*}(\tau) = - \sum_{j=j+1}^q \theta_{j*}(\tau)$. All parameters in (8) calculate the short-term and the long-term relationship between Y_t and the X_t . Thus, it can be captured in the following long-run quantile method by reformulation (8).

$$Y_t = \mu_*(\tau) + X'_t \beta_*(\tau) + R_t(\tau) \quad (9)$$

With

$$\begin{aligned} \beta_*(\tau) &= \gamma_*(\tau) \left(1 - \sum_{i=1}^p \varnothing_{i*}(\tau) \right)^{-1} \text{ and } R_t \\ &= \sum_{j=0}^{\infty} W'_{t-j} \mathcal{E}_{0,j*}(\tau) \sum_{j=0}^{\infty} \rho_{j*}(\tau) U_{t-j}(\tau), \end{aligned}$$

where we let $\mu_*(\tau) = \alpha_*(\tau) \left(1 - \sum_{i=1}^p \varnothing_{i*}(\tau) \right)^{-1}$ and $\mathcal{E}_{0,j*}(\tau) = \sum_{l=j+1}^{\infty} \pi_{l*}(\tau)$, and $\{p_{0*}(\tau), p_{1*}(\tau)\}$,

Moreover, $\{\pi_{0*}(\tau), \pi_{1*}(\tau)\}$ is such that $\sum_{j=0}^{\infty} \rho_{j*}(\tau) L^j \equiv \left(1 - \sum_{j=0}^{\infty} \varnothing_{j*}(\tau) L^j \right)^{-1}$ and

$$(1-L)^{-1} \left(\frac{\sum_{j=0}^p \theta_{j*}(\tau) L^j}{1 - \sum_{j=1}^p \varnothing_{j*}(\tau) L^j} - \frac{\sum_{j=0}^p \theta_{j*}(\tau)}{1 - \sum_{j=1}^p \varnothing_{j*}(\tau)} \right) \equiv \sum_{j=0}^{\infty} \pi_{j*}(\tau) L^j,$$

The static Equation (9) is derived from Y_t 's resolution (18). The residual term $R_t(\tau)$ stands for the repeated-measure variables that are uncorrelated with the long-run (sliding) relation. We capture this by $\beta_*(\tau)$ and call it the long-run parameter. As is clear from its definition, $\beta_*(\tau)$ is defined as a function of $\gamma_*(\tau)$ and $\varnothing_*(\tau) = (\varnothing_{1*}(\tau), \dots, \varnothing_{p*}(\tau))'$, so it can be consistently estimated by the plug-in principle and consistently estimating $\gamma_*(\tau)$ and $\varnothing_*(\tau)$.

Our main interests lie in developing the estimation theory for the long-run parameter $\beta_*(\tau)$. To this end, we reformulate the QARDL process in (10) as

$$Y_t = G'_t \lambda_*(\tau) + \hat{Y}'_t \varnothing_*(\tau) + U_t(\tau) = Z'_t \alpha_*(\tau) + U_t(\tau) \quad (10)$$

where $Z_t = (G'_t, \hat{Y}'_t)' = (G'_t, Y_{t-1}, \dots, Y_{t-p})' = (1, W'_t, \dots, W'_{t-1+1}, X'_t, Y_{t-1}, \dots, Y_{t-p})'$ and $\alpha_*(\tau) = [\lambda_*(\tau)', \varnothing_*(\tau)']' = [\alpha_*(\tau)', \delta_*(\tau)', \gamma_*(\tau)', \varnothing_*(\tau)']' = [\alpha_*(\tau)', \delta_{1*}(\tau)', \dots, \delta_{(q-1)*}(\tau)', \gamma_*(\tau)', \varnothing_*(\tau)']'$ here each element of $\hat{Y}_t$ in (10) has the following specific form:

$$Y_{t-i} = \mu_*(\tau) + X'_{t-i} \beta_*(\tau) \sum_{j=0}^{q-1} W'_{t-j} \varepsilon_{i,j*}(\tau) + K_{t,i}(\tau), \quad i = 1, 2, \dots, p, \quad (11)$$

where we let $\varepsilon_{i,j*}(\tau) = -\beta_*(\tau)$, if $i > j$; and $-\sum_{l=j+1}^{\infty} \pi_{l*}(\tau)$ otherwise, and

$$K_{t,i}(\tau) = \begin{cases} \sum_{j=q-i}^{\infty} W'_{t-i-j} \mathcal{E}_{0,j*}(\tau) + \sum_{j=0}^{\infty} \rho_{j*}(\tau) U_{t-i-j}(\tau) & \text{if } i \leq q; \\ \sum_{j=0}^{i-q-1} W'_{t-q-j} \beta_*(\tau) + \sum_{j=0}^{\infty} W'_{t-i-j} \pi_{j*}(\tau) + \sum_{j=0}^{\infty} \rho_{j*}(\tau) U_{t-i-j}(\tau) & \text{if } i > q. \end{cases}$$

Equation (11) is the lagged version of (7). Reference [29] provided a detailed derivation of (11). As (11) is iteratively used below, we rewrite it more compactly as $\hat{Y}_t = \Gamma_*(\tau)'G_t + K_t(\tau)$ by letting

$$\Gamma_*(\tau) = \begin{bmatrix} \mu_*(\tau) & \mu_*(\tau) & \dots & \mu_*(\tau) \\ \varepsilon_{1,0*}(\tau) & \varepsilon_{2,0*}(\tau) & \dots & \varepsilon_{p,0*}(\tau) \\ \vdots & \vdots & \ddots & \vdots \\ \varepsilon_{1,q-1*}(\tau) & \varepsilon_{2,q-1*}(\tau) & \dots & \varepsilon_{p,q-1*}(\tau) \\ \beta_*(\tau) & \beta_*(\tau) & \dots & \beta_*(\tau) \end{bmatrix} \text{ and } k_t(\tau) = \begin{bmatrix} k_{t,1}(\tau) \\ k_{t,2}(\tau) \\ \vdots \\ k_{t,p-1}(\tau) \\ k_{t,p}(\tau) \end{bmatrix}$$

The QARDL parameters used here are explained as follows. First, we allow the parameters of QARDL to differ from one time to another. Second, we believe that the parameters of QARDL can be influenced by adjusting the invention $U_t(\tau)$. Via statistical surveying, it is possible to discover what percentile happens regularly and what percentile seldom occurs. Therefore, the (dynamic) conditioning variables not only change the size and distribution of Y_t , they also shift their shapes and sizes. In the ARDL context, this condition is equivalent to $\mathbb{E}[\Delta X_t U_t] = 0$ and $\mathbb{E}[\Delta Y_{t-j} U_t] = 0 (j = 1, \dots, p)$ that typically hold if sufficiently large lag orders are given for p and q . Second, it is straightforward to rewrite the QARDL process (1) in the following error correction model (ECM) form:

$$\Delta Y_t = \alpha_*(\tau) + \varsigma_*(\tau)(Y_{t-1} - \beta_*(\tau)'X_{t-1}) + \sum_{j=1}^{p-1} \theta_j^*(\tau) \Delta Y_{t-j} + \sum_{j=0}^{q-1} \theta_j^*(\tau) \Delta X_{t-j} + U_t(\tau), \quad (12)$$

where $\varsigma_*(\tau) = \sum_{i=1}^p \varnothing_{i*}(\tau) - 1$, $\theta_0^*(\tau) = \theta_{0*}(\tau)$, and $j = 1, \dots, p-1$, $\theta_j^*(\tau) = - \sum_{h=j+1}^p \varnothing_{h*}(\tau)$

And

$$\theta_j^*(\tau) = - \sum_{h=j+1}^p \theta_{j*}(\tau).$$

The Wald test determines whether a set of calculated parameters for a statistical model are fittingly equal to any plausible values. If the null hypothesis parameters are equal to 0, it will not affect the parameter estimation results. The method for obtaining the test statistic when given in (13) and can be written is as follows:

$$W = \frac{(\hat{\beta} - \beta_0)^2}{\text{Var}(\hat{\beta})} \quad (13)$$

3. Results

3.1. Analysis Based on Operation Research

Taking climate change mitigation into consideration, the government needs to devote individual capital and hasten investments to combat climate change. Rising revenues from an explosion of carbon trading markets would considerably reduce the quantity of greenhouse gas emissions. The benefits indicators are reported and summarized in Table 1. Based on the GDP per capita, Italy has the highest income out of all G7 countries, followed by Canada, France, and Germany. The USA and Canada are the strongest countries in renewable energy, with 409,924 KTOE and 100,299.6 KTOE energy from renewable sources, respectively, while the rest of the countries are far from them. It could trigger a significant difference among G7 countries' ineffectiveness.

Table 1. Benefit Type Individual Indicator Score.

	GDP (CAP)	Renewable (KTOE)	R&D (% of GDP)
Canada	53,700.68	50,277.58	1.67
France	50,077.79	23,925.63	2.20
Germany	46,242.46	42,182.84	3.13
Italy	54,456.78	26,146.97	3.23
Japan	42,790.06	23,481.84	3.21
UK	41,363.67	16,992.14	1.71
USA	42,135.78	164,099.63	2.83

According to Figure 1, with positive achievements such as a high percentage of research and development in spending, these economies will sustain their environmental conservation programs very soon. Other countries that are perceived as economic powerhouses like Italy, Japan, and Germany are investing more than three percent of their GDP. The UK and Canada must make more efforts to promote the development of renewable energy technologies.

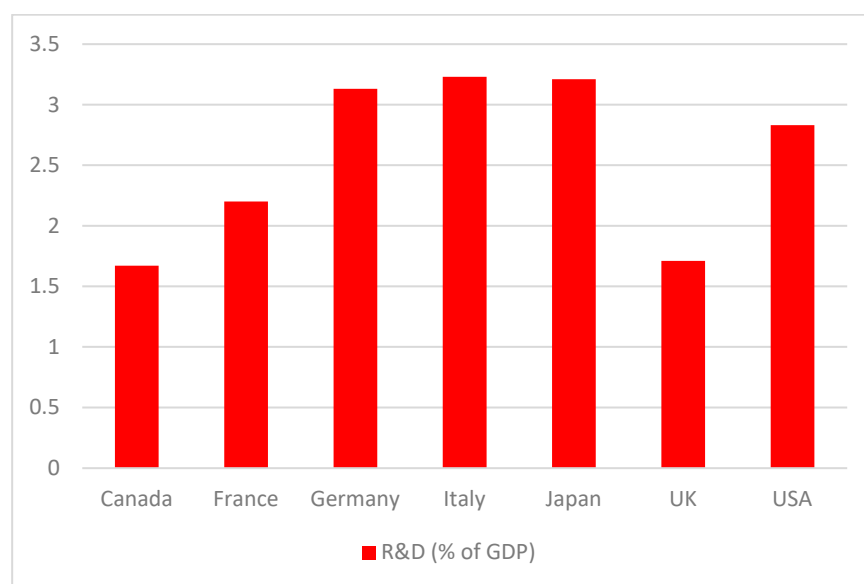
**Figure 1.** R&D expenditure (% of GDP) in G7 economies.

Table 2 displays the data of cost type indicators. In Canada, 15.5 tonnes of greenhouse gases are released per person per year; this is also the lowest among G7 countries. The USA releases 14.9 tonnes of greenhouse gases per capita, but air pollution is still the lowest. Germany is at the top in air pollution, resulting in 450.025 million tonnes of Green House Gas per capita. Italy's GHG is less than some developed countries, but it also has the second-largest air pollution impact among western countries.

Table 2. Cost type Individual Indicator Score.

Country	Air and GHG Emission (TONNE_CAP)	Air Pollution Effects (1,000,000 HAB)
Canada	15.5	180.705
France	4.3	263.182
Germany	8.2	450.025
Italy	5.2	436.249
Japan	8.7	346.338
UK	5.3	336.862
USA	14.9	263.227

The composite index score is depicted in Table 3. The higher the value of an index, the more it can minimize CO₂ emissions by statistical measure analysis. The energy sector should efficiently foster global economic growth, reduce global poverty, and improve world equality. The global energy policy focuses on meeting current, medium, and long-term energy demands [30].

Table 3. The overall composite index score.

Year	Canada	France	Germany	Japan	UK	Italy	USA
2000	0.59	0.61	0.65	0.19	0.23	0.17	0.64
2001	0.57	0.53	0.55	0.24	0.28	0.19	0.61
2002	0.61	0.60	0.71	0.22	0.34	0.15	0.73
2003	0.53	0.67	0.69	0.27	0.30	0.23	0.70
2004	0.64	0.78	0.81	0.31	0.37	0.31	0.79
2005	0.66	0.63	0.79	0.25	0.24	0.28	0.87
2006	0.59	0.55	0.84	0.34	0.53	0.39	0.92
2007	0.77	0.62	0.87	0.37	0.41	0.41	0.91
2008	0.78	0.71	0.79	0.29	0.36	0.43	0.98
2009	0.75	0.63	0.77	0.35	0.45	0.47	0.87
2010	0.84	0.73	0.91	0.21	0.61	0.39	0.88
2011	0.81	0.39	1.00	0.24	0.52	0.61	0.93
2012	0.73	0.51	0.96	0.22	0.63	0.65	0.90
2013	0.84	0.60	0.93	0.42	0.48	0.58	0.89
2014	0.81	0.63	0.81	0.58	0.51	0.53	0.87
2015	0.74	0.68	0.98	0.42	0.47	0.43	0.84
2016	0.61	0.41	0.81	0.33	0.35	0.21	0.81
2017	0.68	0.58	0.93	0.35	0.29	0.42	0.80
2018	0.74	0.42	0.89	0.41	0.51	0.64	0.78

According to the composite index score of G7 nations in Table 3, the year 2011 was best for Germany. It attained the highest score (1) of the composite index, which shows that financial, human capital, and energy indicators were excellent regarding environmental sustainability. The second best in this composite index aggregation is the United States. It maintained an excellent score above 0.90 five times out of nineteen years in the given period, while it also faces fewer fluctuations during the entire period. Here, the maximum and minimum frequency was from 0.98 to 0.61. The third reasonable performer in this regard for the composite index is Canada. The highest index score of Canada was 0.84, while the lowest score was 0.53. Unfortunately, the rest of the G7 countries did not perform well as per the given indicators in the composite index.

According to Figure 2, the combined effect of financial, human, and energy index on the environment are also mixed as per the individual scores of these G7 economies. Out of the seven countries, two (Germany and the USA) perform the best, and one country's performance (Canada) is acceptable. In comparison, the rest of the three countries (Japan, Italy, and the UK) are found to be inferior performers in this lineup. Therefore, no evidence was found regarding the combined policy effect of this group of G7 countries.

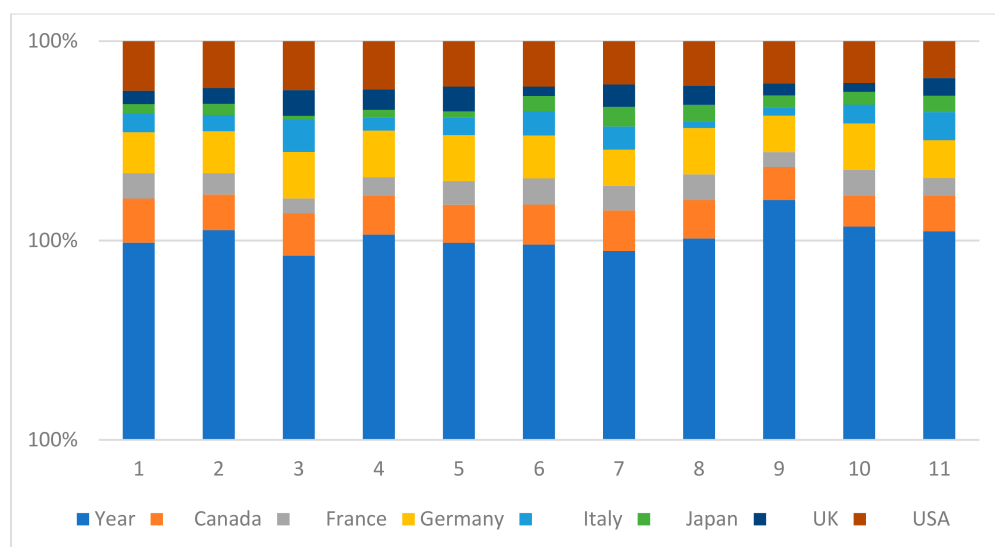


Figure 2. Overall composite index score.

3.2. Analysis Based on QARDL Technique

The statistical summary and the unit root result of the underline dataset presented in Table 4.

Table 4. Unit root test results and statistics summary.

Variable	FI	HCI	EI	ENI
JarqueeBera test	8.3442	12.3476	9.7482	11.4564
Probability	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ADF (Level)	−1.5434	−1.9863	−1.9321	−2.354
ADF (D)	−5.9341 ***	−7.7633 ***	−5.6424 ***	−5.4112 ***
ZA (Level)	−2.8765	−2.6531	−2.9766	−3.1226
ZA (D)	−6.8771 ***	−7.1877 ***	−7.8767 ***	−11.3221 ***
Mean	16.0985	0.9843	5.0922	4.0034
Standard Deviation	0.9536	0.0674	2.4363	1.8741
Minimum	12.5437	1.3685	9.7665	6.7748
Maximum	18.5633	0.0043	0.3789	0.2655
Skewness	0.376	−0.1713	0.6531	−0.2337
Kurtosis	2.921	2.7451	2.0546	3.0092

Note: Here *** indicates a 1% level of significance.

Here, the unit root test is applied in Table 5 on all the variables before performing the QARDL. Statistical analysis results demonstrate that while FI, HCI, EI, and ENI are not necessary at the different quantiles, they are constant at quantile. The stationarity held at unique quantile means that the unit root problem's null hypothesis should be dismissed. This shows that the unit root occurs in all sample variables, and hence the findings are robust and consistent. It is essential to analyze the relationship between the dependent and independent variables.

Table 6 shows the findings for the OLS and Quantile Estimates. In this case, the intercept term is $\alpha^*(\tau)$, and the coefficient value of the error correction term for each quantile is defined as $\rho^*(\tau)'$. The intercepts are essential and have a negative symbol in all the samples. This analysis showed that the coefficient of EI in the calculation was statistically significant and negatively affected. EI's coefficient sign is consistent; it statistically indicates a strong correlation with the dependent, i.e., environmental or ENI, component. The findings of long-term projections based on the ARDL model also support QARDL's performance. The findings show that technological progress in renewable energy by research and develop-

ment plays a significant role in environmental quality and regulates the environmental deterioration.

Table 5. Empirical data for the quantile unit root test.

τ	FI		HCI		EI		ENI	
	$\hat{a}$	t -test	$\hat{a}$	t -test	$\hat{a}$	t -test	$\hat{a}$	t -test
q05	1.0542	−1.6754	1.4721	−1.3264	1.4721	−1.6778	0.9862	−1.7018
q10	1.0653	−1.6643	1.6364	−1.9413	1.6364	−1.6614	0.9655	−1.6327
q15	1.0433	−1.7432	0.9834	−1.9262	0.9834	−1.6893	0.9833	1.7184
q20	0.9855	−1.5433	0.9921	−1.4353	0.9921	1.6385	0.9291	1.6635
q25	0.9831	−1.6576	0.9716	−1.3488	0.9716	−1.6212	0.7916	1.7028
q30	0.9902	−1.6938	0.9064	1.6643	0.9064	−1.6315	0.8945	1.6926
q35	0.9672	−1.6681	0.9782	1.6715	0.9782	−1.6127	0.7965	1.6864
q40	0.9566	−1.5832	0.9654	1.6886	0.9654	1.6363	0.9581	−1.6386
q45	0.9905	−1.4328	0.9991	1.6231	0.9007	1.6835	0.9983	−1.6815
q50	0.9416	−1.0943	1.4675	−1.5432	1.4675	1.6381	0.9637	−1.6629
q55	0.9433	−1.6922	0.9848	−1.6588	0.9848	−1.6265	0.9573	−1.6978
q60	0.9643	−1.5432	0.9934	−1.1125	0.9934	−1.6928	0.9348	−1.7056
q65	0.9322	−1.4348	0.9586	1.6753	0.9586	−1.6578	0.9866	−1.6354
q70	0.9544	−1.6834	0.9473	1.8012	0.9473	−1.6953	0.9711	−1.6155
q75	1.0543	−1.7043	0.9744	1.6391	0.9744	−1.6734	0.9464	−1.6983
q80	1.008	−1.7321	0.9584	1.7073	0.9584	−1.6654	0.9158	−1.6319
q85	1.1355	−1.6704	0.9556	1.7783	0.9556	−1.6875	0.9676	−1.7063
q90	1.0732	−1.6823	0.9732	−1.6835	0.9732	−1.6637	0.9366	−1.6626
q95	0.9987	−1.6788	0.9858	−1.7318	0.9858	−1.8697	0.9544	−1.7073

Table 6. Results for OLS and Quantile Estimation.

Panel (A) Linear ARDL						
Variables	α^*	ρ^*	β_{FI}	β_{HCI}	β_{EI}	β_{ENI}
	3.7633 ***	−0.25221 ***	1.1264 **	2.2059 **	1.1092 ***	1.0737 **
	1.4881	0.09416	0.6239	1.0018	0.4501	0.5055
Panel (B) Quantile ARDL						
Variables	$\alpha^*(\tau)$	$\rho^*(\tau)$	FI(τ)	HCI(τ)	EI(τ)	ENI(τ)
q05	0.9363 ** (0.448)	−0.0800 ** (0.0364)	0.764 ** (0.355)	0.1836 (0.1322)	0.4742 ** (0.2511)	0.1701 (0.1142)
q10	0.3355 * (0.1881)	−0.0723 *** (0.0321)	0.6237 ** (0.3238)	0.2165 (0.1432)	0.1182 * (0.0704)	0.1839 (0.1151)
q15	0.7628 ** (0.3815)	−0.0563 * (0.0325)	0.2264 (0.1601)	0.2554 *** (0.1118)	0.2999 ** (0.1417)	0.1755 ** (0.0943)
q20	0.2735 (0.1881)	−0.0935 *** (0.0415)	0.1264 (0.1078)	0.2155 * (0.1121)	0.4823 ** (0.2599)	0.1932 ** (0.1065)
q25	0.5711 ** (0.2754)	−0.0852 ** (0.0381)	0.3011 * (0.1777)	0.1154 (0.0701)	0.1889 *** (0.0701)	0.1378 * (0.0801)
q30	0.5226 (0.3517)	−0.0629 ** (0.0322)	0.1388 * (0.0811)	0.0059 (0.0038)	0.1001 ** (0.0533)	0.4001 * (0.2367)
q35	0.4673 (0.2844)	−0.0714 ** (0.0366)	0.0766 *** (0.0327)	0.0069 * (0.0041)	0.3756 (0.2307)	0.3531 * (0.2033)
q40	0.6527 * (0.3749)	−0.0834 *** (0.0164)	0.0964 ** (0.0442)	0.0847 ** (0.0418)	0.4106 (0.2551)	0.2588 ** (0.1301)
q45	0.0875 (0.0683)	−0.0357 * (0.0214)	0.0768 ** (0.0426)	0.0577 ** (0.0316)	0.5125 ** (0.2718)	0.1906 * (0.1103)
q50	0.5549 ** (0.2682)	−0.0332 *** (0.0146)	0.1188 * (0.0711)	0.0468 ** (0.0216)	0.5125 (0.3563)	0.0873 ** (0.0432)
q55	0.3358* (0.1981)	−0.0734 *** (0.0315)	0.1092 ** (0.0514)	0.1009 * (0.0581)	0.4491 ** (0.2151)	0.1334 * (0.0748)
q60	0.6942 ** (0.3737)	−0.0791 *** (0.0347)	0.0944 ** (0.0447)	0.2256 * (0.1299)	0.2358 (0.1431)	0.3701 * (0.2101)
q65	0.4652 * (0.2812)	−0.0835 ** (0.0426)	0.0114 (0.0102)	0.3123 (0.1957)	0.3575 * (0.2156)	0.4447 ** (0.2105)

Table 6. Cont.

Panel (B) Quantile ARDL						
Variables	$\alpha^*(\tau)$	$\rho^*(\tau)$	FI(τ)	HCI(τ)	EI(τ)	ENI(τ)
q70	0.1458 (0.4881)	−0.0543 ** (0.0295)	0.1373 * (0.0772)	0.2466 * (0.1401)	0.1222 *** (0.0412)	0.5076 (0.3337)
q75	0.2756 * (0.1534)	−0.0583 *** (0.0232)	0.1755 (0.9244)	0.0894 *** (0.0399)	0.6002 ** (0.2739)	0.1273 ** (0.0611)
q80	0.6583 ** (0.3543)	−0.0532 *** (0.0236)	0.1374 (0.8663)	0.1006 ** (0.0512)	0.3321 ** (0.1531)	0.5055 ** (0.2638)
q85	0.8257 * (0.4637)	−0.0599 * (0.0354)	0.0526 ** (0.0254)	0.3677 *** (0.1146)	0.6299 ** (0.3018)	0.2288 ** (0.1235)
q90	0.7005 ** (0.3217)	−0.0357 * (0.0215)	0.7237 ** (0.3671)	0.4132 ** (0.2101)	0.6009 * (0.3507)	0.3192 ** (0.1644)
q95	0.7432 * (0.4183)	−0.0316 * (0.0180)	0.6226 ** (0.3164)	0.0089 *** (0.0027)	0.7011 ** (0.3564)	0.0954 *** (0.0402)

Note: Here ***, **, and * indicate 1%, 5%, and 10% level of significance, respectively.

According to Table 7, statistical data indicate that the observed F-statistic is statistically higher than the upper and lower bound values. The above fact indicates a clear correlation between economic complexity and energy use with environmental effects. Wald statistic results show substantial rejection of the null hypothesis about error correction terminology and cointegration. It shows that CO₂ emissions in the G7 had a non-linear relationship with economic complexity and energy consumption. The Wald test and Levene's test showed that the researchers obtained enough proof to reject the null hypothesis on parameters constancy. Based on the Wald test results, the null hypothesis is rejected for the cointegrated heteroskedasticity set parameters due to its significance at the long-run and short-run stages.

Table 7. Diagnostic inspection with Bound and Wald tests.

Panel (A) Bounds test for Linear ARDL								
	10%		5%		1%		p-value	
F	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
T	3.456	5.512	4.543	6.534	4.267	6.321	0.064	0.093
	−2.431	−3.156	−3.653	−5.347	−3.423	−4.652	0.045	0.059
Panel (B) Wald test for QARDL								
$\rho^*(\tau)$	FI(τ)	HCI(τ)	EI(τ)	ENI(τ)				
77.43 ***	83.78 ***	173.53 ***	58.32 ***	39.76 ***				
0.000	0.000	0.000	0.000	0.000				

Note: Here, *** indicates a 1% level of significance.

3.3. Discussion

This study attempts to probe the role of human capital and technological innovation in a sustainable environment to attain SDGs in G7 economies. For this purpose, four main indexes have been developed. According to the empirical results of QARDL, human capital factors positively impact the sustainable environment in G7 economies. Outcomes suggest that the higher the level of human capital in these economies, the higher the environmental quality will be, and the more comfortable it will be to achieve SDGs. These findings are also in line with the previous study of [31], who did an empirical analysis on Guangdong province by using the panel data of 21 cities from 2000 to 2016, and with [32] for environmental regulation and human capital level of China throughout from 1990 to 2016. Therefore, world-leading organizations are putting their efforts, time, and money into highlighting the importance of human capital in SDGs' success. In this respect, Proximity Designs used human-centered architecture to boost the livelihood of farmers in Myanmar; the Skoll Foundation acquired "Model for Change: Developing Human Capital" portfolio in February 2013; Camfed provides empowerment programs that provide women access in developing countries such as Nigeria to education, health care, skills training, and microfinance; and Medic Mobile provides mobile and online

applications for healthcare professionals to interact with patients in remote areas. All these agendas represent conventional methods of promoting human capital that are overturned by frequent global growth leaders as agents for the changes.

The empirical outcomes of technological revolutions also have a positive impact on a sustainable environment. In this context, the technological revolutions towards carbon-free energy and production process are helping G7 economies achieve SDGs. It has been empirically tested that technological innovation in the energy sector could help in achieving sustainable environmental conditions with sustainable economic development. These empirical results are aligning with the studies of [33,34]. It is a matter of physical capital and human capital investments and policy, regulatory, R&D, and other stakeholders' support and involvement. Countries could boost their innovation potential by evaluating their success and using their capabilities, and fixing their limitations, by learning from best practices of emerging countries as innovation leaders at all levels of income. Technological developments allow a more sustainable solution for long-term development planning. The trade-off between sustainability and the economy is one of the critical economic issues. Pathways can be chosen based on individuals' choices, such as the government, foreign organizations, customers, private businesses, and educational institutions. We face the significant problem of environmental destruction worldwide, and technology offers ways to fix this problem.

The index of energy contributes positively in the process of a sustainable environment. Here, the higher amount of finance in the form of R&D (percentage of GDP) in energy and renewable energy production and innovation, the higher the sustainable environment in the G7 economies will be. Inclusive green growth is the pathway to sustainable development. The studies of [35,36] also concluded that a higher net worth of R&D to promote renewable energy projects or technologies would help in achieving sustainable environmental conditions. In addition, Reference [37] empirically testified that the only way to resolve economic and environmental disparities is to have an economy and climate that are both green and yet very efficient. The results of the financial index show a positive impact on a sustainable environment. This indicates that the higher the financial liberalization, the higher will be the ability of G7 countries to protect the environment within the given criteria of SDGs. Therefore, financial ability matters significantly in the process of sustainable growth and environmental protection.

There is a vital connection between renewable energy use, innovation, and economic development in this respect. Our findings show that economic development in terms of the financial index and technical advancement through R&D in renewable energy has a significant and positive impact on noncarbon and green energy production. It supports energy supply policies to encourage coherent energy supply and economic development on a long-term basis [38]. The long-lasting balance between real GDP, renewable consumption, and short-term bi-directional causality between renewable energy consumption and economic growth has also been confirmed in this regard [39]. There is a hint that the practical use of renewable energy sources is of low know-how.

Failure to meet SDGs may also be attributed to the lack of financial support for incorporating a higher level of renewables in the energy mix. There can also be a dual interconnection between the consumption of renewable energy and GDP growth. Financial assistance is also required as the wealthiest nations can use renewable energy [40]. However, the results for the country-specific studies indicate that the causality varies from energy consumption to economic growth in most of these studies. We can assume that energy is connected to economic growth; therefore, energy supply shocks can adversely affect economic growth [41]. This finding highlights the benefits of government initiatives such as tax credits for developing renewable energies, renewable energy rebates, and expectations in renewable energy portfolios are critical in this process.

4. Conclusions

This study assesses human capital growth and technological revolutions in a carbon-free energy system for a sustainable environment to pursue sustainable development goals. For this purpose, four separate indexes were identified—the financial index, the energy index, the human index, and the environmental index—based on nineteen years of a G7 economy dataset. The results are significant because there are fears that the economic growth of the G7 economies would alter economic factors and environmental change. The QARDL method results confirm that human capital contributes significantly and positively to the process of the carbon-free economy of G7 nations. Due to human development, the process of SDGs has become much smoother and achievable. Technological innovation is another source of sustainable environment and development in these economies. The findings show that renewable energy technical advancement employing R&D may help to control carbon emissions and boost sustainable growth. Therefore, renewable energy production and consumption innovation contribute positively to the achievement of SDGs. In G7 economies, renewable sources of energy are the leading indicators of a sustainable climate. The higher the R&D investments for traditional and green energy technologies, the lower will be the carbon emissions from clean energy developments and energy quality gains. Therefore, decreased carbon emissions are critical to global warming and its relation to energy use and economic determinants. The growth of human resources and technological advances in these economies contribute significantly to green energy sources. The carbon-free pathway to energy should be viable and sustainable, requiring a substantial commitment to technological change [42]. Economic growth also has a vital role in a sustainable environment. Without financial liberalization and sufficient investment in renewable energy and innovative technologies, the carbon-free globe dream will never come true.

Policy Implication

Technology and innovation strategy for growth should be aligned with the 2030 Plan for Sustainable Development. Economic development and environmental protection are a positive and critical feature of each other. It is crucial to close the gap between countries' capabilities to achieve this goal. Developing countries should embark on a technological convergence if they wish to compete with developed countries in the 21st century.

- One way to succeed in human capital growth is to have a favorable policy condition to fulfill their potential. For instance, individuals without access to the internet and without the right to express their views cannot influence their cultures or choose their future.
- Individuals' welfare has been identified as one of the drivers of economic growth, so policymakers concentrate on improving these public services. Since the human life span is relatively limited and finite, human sustainability depends on continuous maintenance during one's lifetime. Human survival requires substantial investment in education and skill-building for a minimum of two to three decades to realize the potential of all [43].
- Green energy is an essential aspect of a sustainable climate. The improvement of air quality is a significant factor for climate change. The generation of energy from waste is a modern technology that turns garbage into energy and can substitute fossil fuels. Green boilers use less energy than conventional boilers and make lower emissions.
- To ensure the economic growth of many developed countries, technology transformation is a prerequisite. Power generation is a good example. As plants have already been developed in the industrialized world, the technological developments are now in pace and can be extended to achieve energy efficiency in developing densely populated regions.
- To make technologies more consistent with the world environmental pressures that will affect them, effective global and national economic policies and management strategies that include the concept of environmental sustainability are required.

- It is necessary to enable and support recipient governments and organizations to leverage environmental friendly innovations developed by both the public and private sectors.

Author Contributions: This research paper contributed by the authors mentioned above in the following way: conceptualization, done by (Q.A.); methodology, performed by (H.S.); software and validation, performed by (S.A.A.); formal analysis done by (A.S.S.); investigation, resources, data curation, performed by (A.B.K.); writing—original draft preparation done by (H.S.); writing—review and editing (S.u.R.); visualization, and supervision by (M.A.). All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable. Data is available with corresponding author(s) and will be provided on demand.

Acknowledgments: It is hereby acknowledged that (H.S.) & (Q.A.) have an equal contributor to this manuscript.

Conflicts of Interest: We declare no conflict of interest.

References

- Ingrao, C.; Rana, R.; Tricase, C.; Lombardi, M. Application of Carbon Footprint to an agro-biogas supply chain in Southern Italy. *Appl. Energy* **2015**, *149*, 75–88. [CrossRef]
- UN DESA, World Population Expected to Reach 9.7 Billion by 2050, United Nations Department of Economic and Social Affairs. 2015. Available online: <https://www.un.org/en/development/desa/news/population/2015-report.html> (accessed on 12 December 2020).
- Ignatius, M.; Wong, N.H.; Jusuf, S.K. Urban microclimate analysis with consideration of local ambient temperature, external heat gain, urban ventilation, and outdoor thermal comfort in the tropics. *Sustain. Cities Soc.* **2015**, *19*, 121–135. [CrossRef]
- World Health Organization. How Air Pollution Is Destroying Our Health. WHO. 2018. Available online: <https://www.who.int/news-room/spotlight/how-air-pollution-is-destroying-our-health> (accessed on 6 December 2020).
- Schaffer-Smith, D.; Swenson, J.J.; Bóveda-Penalba, A.J. Rapid conservation assessment for endangered species using habitat connectivity models. *Environ. Conserv.* **2016**, *43*, 221–230. [CrossRef]
- World Economic Forum (WEF). Oceans | Explore | TOPLINK, Mapping Global Transformations. 2018. Available online: <https://toplink.weforum.org/page/aboutPublicTM> (accessed on 6 December 2020).
- World Economic Forum (WEF). The Global Human Capital Report. 2017. Available online: <https://www.weforum.org/reports/the-global-human-capital-report-2017> (accessed on 15 December 2020).
- Bennion, E.P.; Ginosar, D.M.; Moses, J.; Agblevor, F.; Quinn, J.C. Lifecycle assessment of microalgae to biofuel: Comparison of thermochemical processing pathways. *Appl. Energy* **2015**, *154*, 1062–1071. [CrossRef]
- Martins, P.M.G. Structural change: Pace, patterns and determinants. *Rev. Dev. Econ.* **2019**, *23*, 1–32. [CrossRef]
- Kato, M. Founders' human capital and external knowledge sourcing: Exploring the absorptive capacity of start-up firms. *Econ. Innov. New Technol.* **2020**, *29*, 184–205. [CrossRef]
- Khalili, N.R.; Duecker, S.; Ashton, W.; Chavez, F. From cleaner production to sustainable development: The role of academia. *J. Clean. Prod.* **2015**, *96*, 30–43. [CrossRef]
- Cook, A.; Ehrlich, I. Was higher education a major channel through which the US became an economic superpower in the 20th century? *J. Asia Pac. Econ.* **2018**, *23*, 515–553. [CrossRef]
- Vázquez Muñoz, J.A.; Camacho Acevo, J.F. Technological progress, capital accumulation and economic growth in Latin America | Progreso tecnológico, acumulación de capital y crecimiento en América Latina. *Investig. Econ.* **2019**, *78*, 307.
- Schot, J.; Steinmueller, W.E. Three frames for innovation policy: R&D, systems of innovation and transformative change. *Res. Policy* **2018**, *47*, 1554–1567. [CrossRef]
- Pigliatille, I.; Marseglia, G.; Pisello, A.L. Investigation of CO₂ Variation and Mapping Through Wearable Sensing Techniques for Measuring Pedestrians' Exposure in Urban Areas. *Sustainability* **2020**, *12*, 3936. [CrossRef]
- Gault, F. Defining and measuring innovation in all sectors of the economy. *Res. Policy* **2018**, *47*, 617–622. [CrossRef]
- Roy, P.; Dias, G. Prospects for pyrolysis technologies in the bioenergy sector: A review. *Renew. Sustain. Energy Rev.* **2017**, *77*, 59–69. [CrossRef]
- Viteri, J.P.; Henao, F.; Cherni, J.; Dyner, I. Optimizing the insertion of renewable energy in the off-grid regions of Colombia. *J. Clean. Prod.* **2019**, *235*, 535–548. [CrossRef]

19. Ma, X.; Wang, Y.; Wang, C. Low-carbon development of China's thermal power industry based on an international comparison: Review, analysis and forecast. *Renew. Sustain. Energy Rev.* **2017**, *80*, 942–970. [\[CrossRef\]](#)
20. Marsegia, G.; Vasquez-Pena, B.F.; Medaglia, C.M.; Chacartegui, R. Alternative Fuels for Combined Cycle Power Plants: An Analysis of Options for a Location in India. *Sustainability* **2020**, *12*, 3330. [\[CrossRef\]](#)
21. Bishoge, O.K.; Zhang, L.; Mushi, W.G. The Potential Renewable Energy for Sustainable Development in Tanzania: A Review. *Clean Technol.* **2018**, *1*, 70–88. [\[CrossRef\]](#)
22. Hatefi, S.; Torabi, S. A common weight MCDA–DEA approach to construct composite indicators. *Ecol. Econ.* **2010**, *70*, 114–120. [\[CrossRef\]](#)
23. Hatefi, S.M.; Moshashae, S.M.; Mahdavi, I. A Bi-Objective Programming Model for Reliable Supply Chain Network Design under Facility Disruption. *Int. J. Integr. Eng.* **2019**, *11*, 11. [\[CrossRef\]](#)
24. Reig-Martínez, E.; Gómez-Limón, J.A.; Picazo-Tadeo, A.J. Ranking farms with a composite indicator of sustainability. *Agric. Econ.* **2011**, *42*, 561–575. [\[CrossRef\]](#)
25. Munda, G.; Nardo, M. Noncompensatory/nonlinear composite indicators for ranking countries: A defensible setting. *Appl. Econ.* **2009**, *41*, 1513–1523. [\[CrossRef\]](#)
26. Cook, W.D.; Kress, M. Data envelopment analysis in the presence of both quantitative and qualitative factors. *J. Oper. Res. Soc.* **1996**, *47*, 945. [\[CrossRef\]](#)
27. Johnston, R.J.; Besedin, E.Y.; Holland, B.M. Modeling Distance Decay Within Valuation Meta-Analysis. *Environ. Resour. Econ.* **2019**, *72*, 657–690. [\[CrossRef\]](#)
28. Cho, J.S.; Kim, T.-H.; Shin, Y. Quantile cointegration in the autoregressive distributed-lag modeling framework. *J. Econ.* **2015**, *188*, 281–300. [\[CrossRef\]](#)
29. Pesaran, M.H.; Shin, Y. An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In *Proceedings of the Econometrics and Economic Theory in the 20th Century*; Strom, S., Ed.; Cambridge University Press (CUP): Cambridge, UK, 2012; pp. 371–413.
30. Kim, T.I.; Shin, Y.H.; White-Traut, R.C. Multisensory intervention improves physical growth and illness rates in Korean orphaned newborn infants. *Res. Nurs. Heal.* **2003**, *26*, 424–433. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Mohsin, M.; Rasheed, A.; Sun, H.; Zhang, J.; Iram, R.; Iqbal, N.; Abbas, Q. Developing low carbon economies: An aggregated composite index based on carbon emissions. *Sustain. Energy Technol. Assessments* **2019**, *35*, 365–374. [\[CrossRef\]](#)
32. Liao, L.; Du, M.; Wang, B.; Yu, Y. The Impact of Educational Investment on Sustainable Economic Growth in Guangdong, China: A Cointegration and Causality Analysis. *Sustainability* **2019**, *11*, 766. [\[CrossRef\]](#)
33. Wen, H.; Dai, J. Trade openness, environmental regulation, and human capital in China: Based on ARDL cointegration and Granger causality analysis. *Environ. Sci. Pollut. Res.* **2019**, *27*, 1789–1799. [\[CrossRef\]](#) [\[PubMed\]](#)
34. Nisham, A.M.K.; Muhammed, A.V. Role of energy use in the prediction of CO₂ emissions and economic growth in India: Evidence from artificial neural networks (ANN). *Environ. Sci. Pollut. Res.* **2020**, *27*, 23631–23642. [\[CrossRef\]](#)
35. Bento, J.P.C.; Moutinho, V. CO₂ emissions, non-renewable and renewable electricity production, economic growth, and international trade in Italy. *Renew. Sustain. Energy Rev.* **2016**, *55*, 142–155. [\[CrossRef\]](#)
36. Iram, R.; Zhang, J.; Erdogan, S.; Abbas, Q.; Mohsin, M. Economics of energy and environmental efficiency: Evidence from OECD countries. *Environ. Sci. Pollut. Res.* **2019**, *27*, 3858–3870. [\[CrossRef\]](#)
37. Baloch, Z.A.; Tan, Q.; Iqbal, N.; Mohsin, M.; Abbas, Q.; Iqbal, W.; Chaudhry, I.S. Trilemma assessment of energy intensity, efficiency, and environmental index: Evidence from BRICS countries. *Environ. Sci. Pollut. Res.* **2020**, *27*, 34337–34347. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Iqbal, W.; Yumei, H.; Abbas, Q.; Hafeez, M.; Mohsin, M.; Fatima, A.; Jamali, M.A.; Jamali, M.; Siyal, A.; Sohail, N. Assessment of Wind Energy Potential for the Production of Renewable Hydrogen in Sindh Province of Pakistan. *Processes* **2019**, *7*, 196. [\[CrossRef\]](#)
39. Omri, A. An International Literature Survey on Energy-Economic Growth Nexus: Evidence from Country-Specific Studies. *SSRN Electron. J.* **2015**, *38*, 957–959. [\[CrossRef\]](#)
40. Apergis, N.; Payne, J.E. Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy* **2010**, *38*, 656–660. [\[CrossRef\]](#)
41. Ntanos, S.; Skordoulis, M.; Kyriakopoulos, G.; Arabatzis, G.; Chalikias, M.; Galatsidas, S.; Batzios, A.; Katsarou, A. Renewable Energy and Economic Growth: Evidence from European Countries. *Sustainability* **2018**, *10*, 2626. [\[CrossRef\]](#)
42. Ozturk, I. A literature survey on energy–growth nexus. *Energy Policy* **2010**, *38*, 340–349. [\[CrossRef\]](#)
43. European Commission She Figures 2018. 2019. Available online: https://ec.europa.eu/info/publications/she-figures-2018_en (accessed on 20 December 2020).