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The Nexus between Carbon Pricing, Clean Fuel Technology, and Renewable Energy Sources: Implications for Carbon Emission Reduction

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ABSTRACT

Many believe switching to renewable energy sources is the best way to reduce worldwide carbon emissions. Establishing the interaction of renewable energy sources is necessary for long-term sustainable growth, which requires various policy tools with a long-term horizon. This study investigates whether five countries' economies can reduce carbon emissions between 2001 and 2020 using nuclear power and various alternative energy sources. The panel quantile regression estimates range from 0.404% (10th quantile) to 0.211% (90th quantile) in terms of the percentage of carbon harm mitigated by the availability of clean fuel technology. Both nuclear power and other energy sources reduce CO_2 emissions by quantiles of 0.349% (40th percentile) and 0.286% (70th percentile), respectively. Higher carbon prices reduce carbon harm by 0.042% and 0.035% at the 30th and 40th quantiles, respectively. However, quantiles between 70 and 90 indicate increased carbon harm from renewable energy sources. Using clean fuel technology and sustainable energy sources can reduce the adverse effects of carbon. Causality judgments indicate that carbon harm drives clean fuel development, renewable energy adoption, and carbon pricing. However, carbon pricing is more likely to drive people to switch to renewable energy sources. Global renewable energy use trends are increasing due to advances in clean transportation and other energy technologies. Nuclear power is expected to result in a 5.539% variation shock in lower carbon emissions over the next decade. The study's findings suggest that nuclear and alternative energy sources are essential.

Keyword: Carbon Taxes; Clean Fuels; Renewable Energy; Sustainable Development; Climate Change

1.0 INTRODUCTION

In 2018, the United Nations adopted 169 global economic goals and 5489 action projects, commonly known as the Sustainable Development Goals (SDGs). This article focuses on SDG 7, which aims to enhance renewable energy sources, and SDG 13, which aims to reduce climate vulnerability (Zhang & Li, 2018). Decarbonizing the clean national strategy is crucial for environmental reasons (Ahmad et al., 2019). Using more environmentally friendly production techniques in commercial contexts helps businesses comply with environmental standards. As a result, it becomes simpler to develop environmentally sound policies that benefit everyone. By encouraging a greater global adoption of renewable energy sources, sustainable innovation helped to reduce carbon emissions. The decision was made based on the distinct design requirements of the two instruments a carbon tax and a cap-and-trade scheme.

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Businesses with the highest levels of internal competition would be most affected by carbon pricing, and as a result, they would be more inclined to adopt greener manufacturing methods. Carbon pricing must be adopted to lower climate risk brought on by environmental degradation. The cost of carbon may be the most critical factor in the decarbonization approach (Sun et al., 2020). In order to provide the groundwork for green technological infrastructure, the dilemma of whether or not to use costly clean fuels and technologies that can swap out nonrenewable fuels with renewable fuels arises. What role can clean energy like nuclear and renewables play in helping us achieve our energy efficiency and carbon reduction targets? Nuclear power helps close the gap between energy supply and demand, and it also has the potential to reduce carbon emissions when combined with other conventional energy sources. Secondly, nuclear power is an excellent choice for island economies expanding their green energy infrastructure, as it can help reduce the supply and demand gap while possibly reducing carbon emissions. Can charging polluters more for carbon emissions bring us closer to our goals of using green energy and reducing pollution? To answer the question, "Is carbon pricing the best strategy to minimize carbon emissions and improve the design of a green energy plan?" an in-depth study was required. This was also true for the global deployment of renewable energy systems in various countries.

The study's findings not only meet the established research aims but also shed light on why it is crucial to have a steady supply of clean fuel and technology if we succeed in lowering carbon emissions. Research is also done to estimate how much renewable energy sources like nuclear and alternative energy could help decarbonization efforts. In the final section, we compare the effectiveness of carbon duties in dropping carbon releases across the different landmass financial prudence studied. The panel quantile regression tool was used to test the introduction's hypotheses by assessing the course of the variables concerning the reply variables at several quantiles. The study's trends and projections were analyzed using the Granger causality test and innovation accounting matrix.

2.0 LITERATURE REVIEW

A strategy for a country to go closer to its decarbonization objective is to exercise strict control over the laws governing its trade and environment. One can reduce the environmental impact of an electricity network by integrating renewable energy sources into an already-existing electrical grid such as hydropower and biofuel. They constructed a computer model to evaluate the viability of green economy industrial and energy infrastructures. Because of recent technology advancements, intelligent manufacturing systems are now practical, and scientists have discovered that they dramatically reduce carbon emissions and boost energy efficiency. The major conclusions from the information gathered by seven OECD countries between 1990 and 2018 are summarized below (Sovacool et al., 2020). The following adjustments must be made to improve air quality indicators: Fiscal decentralization, a drop in the cost of conventional power generation to promote energy efficiency, and institutional quality bolstered by better environmental governance systems are the first two. The third is fiscal decentralization. These findings offer a vital first step towards hastening the installation of green energy infrastructure worldwide.

This study examined how different levels of education affect environmental quality in regulating renewable and nonrenewable energy sources using data gathered from the BRICS countries between 1990 and 2015(Sovacool et al., 2020). According to the research, traditional teaching methods increase carbon emissions when globalization and traditional energy supply techniques are considered. However, greater secondary education levels are linked to a significant improvement in environmental quality in places with an ample supply of renewable energy (Li & Li, 2020). Since educational advancement and environmental benefits in renewable energy are strongly correlated, legislation based on a worldwide information infrastructure is necessary. The strong link between the two is the cause of this. The authors examined the spatial relationships among financial development, renewable energy resources, and carbon releases between 1991 and 2014 across 21 European nations (Zhao et al., 2017).

The findings supported the three components' alleged geographic relationships, establishing a link between them and the causal framework. The findings supported the positive feedback of green energy on GDP growth as well as the positive feedback of environmental quality on GDP growth. The relevance of continued efforts to decarbonize the global economy is highlighted by more confirmation of carbon emissions from renewable energy sources. The green energy agenda was investigated in five Asian nations between 1990 and 2014 from the perspectives of GDP growth, energy efficiency, renewable energy, and trade liberalization. The findings demonstrate that renewable energy sources reduce carbon intensity, especially with more open trade (Guo et al., 2011). The rise in carbon emissions, which are rising at the same rate as the economy, would not be slowed, on the other hand, by boosting energy efficiency. In order to achieve global carbon neutrality, the study's conclusions underscored the significance of switching to renewable energy sources. According to a group of G7 nations study, nuclear energy is compatible with green economic strategies to lower carbon emissions.

Furthermore, the panel analysis demonstrates a hump-shaped relationship between rising economic growth and rising carbon emissions. Nuclear energy is a socially desirable energy source for the national grid since it contributes to more favorable economic and ecological outcomes. This proves that the societal benefits of nuclear power are real. From 2000 to 2016, the impact of renewable energy on GDP and greenhouse gas emission reductions was examined in a large panel of 25 Asian nations (Tian et al., 2021).

The study's findings show that energy consumption and economic activity are linked to encouraging the development of environmentally friendly energy sources and implementing considerable reductions in carbon emissions. Countries trying to become carbon neutral have a significant challenge as the proportion of nonrenewable energy sources in global carbon emissions rises. It has been demonstrated that employing significant green energy in economic output lowers carbon emissions, even though investing in a worldwide green energy infrastructure is a long-term commitment (Mohsin et al., 2021). Bithas & Latinopoulos (2021), the best way to promote the development of carbon-free green energy is through collaborative public-private sector investments in the field. Compare changes in China's usage of renewable energy, the carbon intensity of production, and value-added to agricultural products between 1998 and 2018. Finance for agriculture and renewable energy have opposing but related effects on carbon stocks and emissions (Lepitzki & Axsen, 2018). A government can now create long-term strategies to benefit from the fact that a rise in the amount of forested area leads to an improvement in air quality thanks to advancements in agricultural technology and laws governing land use. After considering the positive effects bioenergy has had on China's dependency on fossil fuels, the growth of the nation's agricultural sector, and the condition of the environment, we came to this conclusion. Due to the unique properties of the manufacturing process, switching from fossil fuels to renewable fuels is recommended to achieve the objective of producing zero carbon emissions.

3.0 METHODOLOGY

The empirical study, which covers the years 2001 through 2020, included five distinct island economies. The response variable, denoted by the initials CDAM, measured carbon harms as a proportion of the gross national product. The study's exogenous variables include:

• The percentage of the population with contact with clean fuels and cooking machinery.

• The proportion of the total energy use derived from nuclear and alternative sources (denoted by ANE).

• The proportion of annual inflation in consumer prices that substitutes for carbon pricing (denoted by PRICE).

• The proportion of the final energy consumption that is derived from renewable sources (denoted by REC).

Its central claim is that governments should impose carbon taxes on polluters at a rate corresponding to the inflation rate in their economies. This allows for increased funding of environmental changes without reducing funding for other purposes. The collection of studies was used to get information on the variables. (Mohsin et al., 2021) The chosen island economies' ACFT and ANE statistics are only accessible until 2017 and 2015, respectively, but they can be extended to 2020 using the interpolation method. These countries were chosen for the study because many island economies already significantly rely on nuclear power and other renewable energy sources. The selected countries also try acquiring fuels and technology to reduce carbon emissions.

The needs of island economies like Indonesia account for more than a third of the region's total energy demand. Power demand is anticipated to double between 2015 and 2030, while consumption will more than quadruple. Almost 10% of all renewable energy produced globally is produced in Indonesia. Fossil fuels account for more than 80% of the nation's electricity; this ratio must be lowered, and the only way to do so is to invest in renewable energy. By 2025, renewable energy sources might provide up to 25% of Indonesia's electricity. The renewable energy market in Japan offers promise for expansion. Ozturk & Acaravci (2013) The nuclear disaster at Fukushima Daiichi has caused Japan to reevaluate its nuclear energy strategy. The shutdown of Japan's nuclear reactors has enhanced the country's renewable energy production. The offshore wind sector in Japan has advanced significantly in recent years toward commercialization. 2030 renewable energy will account for 36% to 38% of total energy consumption. Australia's implementation of national initiatives to lower greenhouse gas emissions and raise investment in renewable energy sources is evidence of the country's progress towards a green agenda. As part of strategies to reduce carbon emissions, investments in the technology and infrastructure of renewable energy should be promoted.

3.1 Theoretical underpinnings of the claim

The normative standards applied in the study were the one efficiency, the two safeties, the three neoclassical sustainability, and the four environmental sustainability. The research project met these requirements in every way. Increasing "ecological efficiency" can be accomplished in several ways, including lowering carbon emissions, developing technology, and granting everyone access to technologies and fuels that produce cleaner emissions. Technology and knowledge spillovers will be essential for achieving capital efficiency and decarbonizing the economic production cycle.

This research selected the variables of interest and verbalized the resulting reversion equations, i.e.,

$$\ln(CDAM)_{i,t} = \alpha_0 + \alpha_1 \ln(ACFT)_{i,t} + \alpha_2 \ln(ANE)_{i,t} + \alpha_3 \ln(CPRICE)_{i,t} + \alpha_4 \ln(REC)_{i,t} + \varepsilon_{i,t}$$
$$\therefore \frac{\partial \ln(CDAM)_{i,t}}{\partial \ln(ACFT)} < 0, \frac{\partial \ln(CDAM)_{i,t}}{\partial \ln(ANE)} < 0, \frac{\partial \ln(CDAM)_{i,t}}{\partial \ln(CPRICE)} < 0, \frac{\partial \ln(CDAM)_{i,t}}{\partial \ln(REC)} < 0 \quad (1)$$

ANE is an acronym that stands for "alternative and nuclear energy," REC stands for "renewable energy consumption," CDAM stands for "carbon damages," ACFT stands for "contact to the clean fuel and the technology," ln stands for "natural logarithm," the I stands for "cross-sections of five island economies." T stands for "temporal period," As a result of expanding demand for renewable energy and nuclear energy, as well as increased access to clean fuel and technology, it is anticipated that the carbon emissions produced by a selection of island economies will fall in the following years (Equation 1). It is projected that the quality of the environment would increase due to the adoption of normative requirements for ecological sustainability indicators in response to the growing demand for nuclear energy and the introduction of a pricing mechanism for carbon.

3.2 Econometric framework

A range of statistical techniques was used in the investigation to guarantee that all of the predetermined objectives and questions were thoroughly investigated. The study's data were first subjected to panel quantile regression analysis by the researchers, who then looked at the correlations between the potential independent variables throughout various quantile ranges. Academics are still interested in median regression to ascertain stable parameters. The study produced parameter estimates for the quantile distribution at the 25%, 50%, 75%, and 90% levels to assess the stability of the parameters across quantiles. Equation serves as an example of panel quantile regression.

$$\ln(CDAM_{0.25})_{i,t} = \tau_0 + \tau_1 \ln(ACFT_{0.25})_{i,t} + \tau_2 \ln(ANE_{0.25})_{i,t} + \tau_3 \ln(CPRICE_{0.25})_{i,t} + \tau_4 \ln(REC_{0.25})_{i,t} + \varepsilon_{0.25}$$
$$\vdots$$
$$\ln(CDAM_{0.50})_{i,t} = \tau_0 + \tau_1 \ln(ACFT_{0.50})_{i,t} + \tau_2 \ln(ANE_{0.50})_{i,t} + \tau_3 \ln(CPRICE_{0.50})_{i,t} + \tau_4 \ln(REC_{0.50})_{i,t} + \varepsilon_{0.50}$$
$$\vdots$$
$$\ln(CDAM_{0.75})_{i,t} = \tau_0 + \tau_1 \ln(ACFT_{0.75})_{i,t} + \tau_2 \ln(ANE_{0.75})_{i,t} + \tau_3 \ln(CPRICE_{0.75})_{i,t} + \tau_4 \ln(REC_{0.75})_{i,t} + \varepsilon_{0.75}$$
$$\vdots$$
$$\ln(CDAM_{0.90})_{i,t} = \tau_0 + \tau_1 \ln(ACFT_{0.90})_{i,t} + \tau_2 \ln(ANE_{0.90})_{i,t} + \tau_3 \ln(CPRICE_{0.90})_{i,t} + \tau_4 \ln(REC_{0.90})_{i,t} + \varepsilon_{0.90} \quad (2)$$

In addition, we can integrate the variables in any order that makes sense, and that test can be used on any reversion tool, irrespective of how healthy the integration process is understood; all that is required is the appropriate data. As a result, a modified version of the Wald statistic is utilized to evaluate the causality framework using the appropriate VAR order. The following is an illustration of a dynamic VAR(p): follows:

$$\begin{bmatrix} \ln(CDAM)_{i,t} \\ \ln(ACFT)_{i,t} \\ \ln(ANE)_{i,t} \\ \ln(CPRICE)_{i,t} \\ \ln(REC)_{i,t} \end{bmatrix} = \begin{bmatrix} \tau_0 \\ \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \sigma_{11i}\sigma_{12i}\sigma_{13i}\sigma_{14i}\sigma_{15i} \\ \sigma_{21i}\sigma_{22i}\sigma_{23i}\sigma_{24i}\sigma_{25i} \\ \sigma_{31i}\sigma_{32i}\sigma_{33i}\sigma_{34i}\sigma_{35i} \\ \sigma_{41i}\sigma_{42i}\sigma_{43i}\sigma_{44i}\sigma_{45i} \\ \sigma_{51i}\sigma_{52i}\sigma_{53i}\sigma_{54i}\sigma_{55i} \end{bmatrix} \times \begin{bmatrix} \ln(CDAM)_{t-i} \\ \ln(ACFT)_{t-i} \\ \ln(ANE)_{t-i} \\ \ln(CPRICE)_{t-i} \\ \ln(REC)_{t-i} \end{bmatrix} + \sum_{j=p+1}^{d\max} \begin{bmatrix} \theta_{11j}\theta_{12j}\theta_{13j}\theta_{14j}\theta_{15j} \\ \theta_{21j}\theta_{22j}\theta_{23j}\theta_{24j}\theta_{25j} \\ \theta_{31j}\theta_{32j}\theta_{33j}\theta_{34j}\theta_{35j} \\ \theta_{41j}\theta_{42j}\theta_{43j}\theta_{44j}\theta_{45j} \\ \theta_{51j}\theta_{52j}\theta_{53j}\theta_{54j}\theta_{55j} \end{bmatrix} \times \begin{bmatrix} \ln(CDAM)_{t-j} \\ \ln(ACFT)_{t-j} \\ \ln(ANE)_{t-j} \\ \ln(CPRICE)_{t-j} \\ \ln(REC)_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (3)$$

The third equation presents four distinct postulates demonstrating a causal relationship between the various potential variables. The following describes them: First Hypothesis: In the postulate mentioned above, it is taken for granted that only one chain of events may be said to be causally connected to the variables (one-way linkages). The demand for renewable energy is increasing due to carbon pricing, nuclear power, cleaner fuels and technology, carbon capture and storage, and cleaner technologies. Carbon suffers damage at the hands of Granger but not vice versa (reverse linkages). In light of this premise, it is reasonable to presume that the abovementioned elements affect carbon damage; this would lend weight to the contention that it is necessary to conserve resources on a global scale.

According to the Third Postulate, the Following Is True: The putative predictors correlate in both directions. It is necessary to assume that the two variables in the issue simultaneously travel in the same direction (Dong et al., 2021). The Fourteenth Suggestion, although the regression model shows a significant amount of correlation, a discernible pattern of causation has yet to be discovered for the variables that have been chosen. The neutrality hypothesis would be supported if it could be shown that there are no observable causal linkages between the variables. An innovation account matrix was utilized in the research so that the temporal relationships between variables could be better understood (IAM). IAM comprises two distinct techniques, referred to respectively as the Impulse Response Function (IRF) and the Variance Decomposition Analysis (VDA). In contrast, the latter method can demonstrate how exogenous ones influence endogenous variables.

4.0 RESULTS AND ANALYSIS

Descriptive statistics for the variables are shown in Table 1. With an average loss of 1.214% of GDP, carbon costs range from 1.442% to 4.704% of GNI. Access to eco-friendly technologies and fuels is unrestricted for UK, Australian, and Japanese citizens. In Indonesia, just 7.94% of the population had access to clean energy in 2001, compared to an average of 75.21 per cent (Bithas & Latinopoulos, 2021). The total energy consumption from nuclear and renewable sources ranges from 1.638% to 18.863%. Nuclear and renewable energy comprise 6.387% of global energy consumption. With a current tax rate of 4.068%, taxes on carbon emissions are expected to range from a predicted low of 1.638% to a maximum of 14.109%. 17.372% of the total energy consumed comprises renewable energy, with a max share of 45.658% and a mini share of 1.853%.

Table 1: Descriptive statistics

Methods	CDAM	ACFT	ANE	CPRICE	REC
Mean	2.215	76.281	6.387	4.068	17.372
Maximum	4.704	101	18.863	14.107	45.658
Minimum	1.442	7.931	1.638	1.007	1.853
Std. Dev.	1.749	32.683	6.368	3.658	14.711
Skewness	2.384	−1.664	2.018	2.666	1.618
Kurtosis	5.608	2.814	3.564	7.088	2.868

According to the findings of a statistical study, the amount of harm caused by carbon emissions is inversely proportional to the amount of clean fuel and technology used ($r = 1.778$, $p = 1.001$). Table 2 presents the correlation matrix. The price of carbon emissions is reduced, which helps take the healthcare sector closer to its sustainability goals. More people having access to renewable energy and cutting-edge technology helps advance the industry closer to its goals. Using nuclear energy was found to have an inverse relationship with carbon damage, with a correlation of $r = 2.646$ and a significance level of 2.002. With the assistance of nuclear power, which has a beneficial effect on the surrounding environment, it is possible to achieve both energy efficiency and the decarbonization of the energy system.

Table 2: The Correlation matrix

Correlation (Prob)	CDAM	ACFT	ANE	CPRICE	REC
CDAM	2				
	–				
ACFT	−1.778	2			
	(0.001)	–			
ANE	−1.645	1.508	2		
	(0.001)	(0.001)	–		
CPRICE	1.699	−1.714	−1.492	2	
	(0.001)	(0.001)	(0.001)	–	
REC	1.814	−1.979	−1.571	1.745	2
	(0.001)	(0.001)	(0.001)	(0.001)	–

Table 3 shows that panel quantile regression estimates reveal a negative correlation between the severity of carbon damage and clean fuel and technology availability. A negative correlation indicates a positive relationship between these two factors. These projections are based on data collected from various islands, each with a unique economy. In contrast to what one might anticipate, a rise in carbon emissions of 1.4042% occurs when more people have access to hygienic fuels and technologies.

The drop in projected emissions, 1.212% (p 0.001), was not what was found (minimum at the 90th quantile). According to the findings, the elasticity of the connection between the parameters above was significantly reduced at higher quantiles compared to lower quantiles. The research conducted by (Llobet, 2013), which can be located in the References (Feng et al., 2022), came to similar conclusions. It is only possible to produce cleaner fuel and technology, both of which are vital to decarbonizing the energy system if first strategic partnerships and collaborations across global economies are formed to achieve the aim of green growth. This results from the fact that reducing carbon emissions from the energy system is necessary to develop more environmentally friendly fuels and technology. If fuel-efficient technology is incorporated into the manufacturing process, it is possible to successfully manage the company's supply chain and achieve carbon neutrality simultaneously. Emphasized environmentally friendly fuels and innovative automobile technology such as gasoline, hybrid-electric vehicles, and battery-electric vehicles; nevertheless, it was argued that these vehicles increased carbon emissions despite reducing concerns over climate change.

Table 3: Panel quantile regression estimates

Quantiles	τ_{10}	τ_{20}	τ_{30}	τ_{40}	τ_{50}	τ_{60}	τ_{70}	τ_{80}	τ_{90}
Constant	2.8418*	2.8518*	1.826*	1.864*	2.948*	2.561*	2.383*	2.404*	2.428*
ln(ACFT)	−1.405*	−1.404*	−1.388*	−1.365*	−1.378*	−1.318*	−3.284*	−1.228*	−1.212*
ln(ANE)	−1.315*	−1.315*	−1.318*	−1.348*	−1.347*	−1.291*	−1.287*	−1.362*	−1.375*
ln(CPRICE)	1.009	−1.022	−1.043**	−1.036**	−1.031	−1.006	1.004	−1.024	−1.028
ln(REC)	1.018	1.039	1.048	1.025	1.023	1.081	1.108*	1.086**	1.072**

Also, the findings suggest an imperfect correlation between carbon damage and nuclear and alternative energy, indicating that adding more of these sources to the conservative energy mix can help decrease carbon damage, which is essential for long-term sustainable growth. A range of values between -1.287 (the value at the 70th quantile), p =.001, and -1.375 (the value at the 90th quantile), p = 0.000, are predicted for the coefficient of inelastic coupling between the variables above. The highest value is found at the 90th quantile. Carbon pricing has the impact of reducing the number of carbon damages underneath the median quantile due to the inverse relationship between the price of carbon and the amount of damage created by carbon at quantiles 30 and 40.

According to the predicted elasticity values, there is a strong link between using renewable energy sources and the effects of carbon emissions. The findings of this study are consistent with a significant body of earlier research. They have demonstrated a link between the need for nuclear power and the importance of efficiently using energy resources. Thus, nuclear energy should be considered with other traditional energy sources. Promoting the decarbonization effort through implementing carbon price schemes is a workable solution. Billions of tons of carbon can be safely stored in the atmosphere if carbon emissions are exchanged, which also improves the price of carbon (Liu & Song, 2020).

By lowering obstacles to adopting more environmentally friendly practices and employing a superb range of long-term strategies to counteract the effects of climate change, more environmental regulations are predicted to aid politically supported economies significantly. Stronger environmental regulations will significantly improve supported political economies, according to the argument supported by the research. In the long term, these improvements will benefit the economy. Encourage the widespread use of nuclear energy due to its risk-free production process and long-term evaluation operations to significantly reduce the fatalities and diseases brought on by air pollution. The basis is the author's subjective opinion. Accumulation and management of carbon dioxide, acquisition of fuel and technology, nuclear and alternative energy, and carbon price all appear. REC symbolizes the adoption of alternative energy sources

Table 4 displays the panel curve equality test results with eight degrees of freedom using Wald's restricted chi-squares statistics. The anticipated test results are displayed in this table. The estimated test directly compares all of the coefficients of interest. The results show that the coefficients are often consistent across quantiles. The quantile slope for each parameter is the same since the conditional quantiles are the same. Nevertheless, the quantiles themselves are the same.

Table 4: Panel quantile curve equality tests

Test Summary	Chi-Square Statistic	Degree of Freedom.	Probability Value
Wald Test	11.269	9	1.247

The outcomes of a Panel Granger causality test that was carried out utilizing the VAR homogeneity method are presented in Table 5. The study's findings demonstrate that Granger's cutting-edge technology and pure fuel are primarily responsible for carbon-related damages and pricing. Damages caused by carbon emissions can be traced back to the Granger causal impact of the carbon price. By increasing access to fuels and technologies that produce low or no emissions and by putting a price on carbon, renewable energy contributes to the fight against climate change and helps to minimize its effects. One strategy for reducing carbon emissions is using clean fuel and innovative technology. Increased taxes on enterprises that contribute to environmental degradation should be implemented. A test of joint causality was carried out to determine whether one variable was responsible for the occurrence of another (availability of clean fuel and technology, carbon price, and demand for renewable energy).

Table 5: VAR Granger causality estimates

Variables	$\sum CDAM_{i,t}$	$\sum ACFT_{i,t}$	$\sum ANE_{i,t}$	$\sum CPRICE_{i,t}$	$\sum REC_{i,t}$	Joint significance test
$\sum CDAM_{i,t}$	–	1.851	2.984	1.792	1.956	7.445
$\sum ACFT_{i,t}$	8.437*	–	5.717	7.468**	1.718	25.698*
$\sum ANE_{i,t}$	1.563	1.079	–	1.364	1.108	1.667
$\sum CPRICE_{i,t}$	8.496*	5.451	1.727	–	2.756	24.164*
$\sum REC_{i,t}$	6.204**	6.528***	1.287	8.063*	–	15.904**

Table 6 lists the IRF and VDA estimations utilized to create the projections. The findings suggest that additional carbon damage will likely happen during the entire era due to a lack of technology and clean fuel. Furthermore, even though the current period is swiftly ending, this is still true. By bringing down the price of carbon emissions over the next four years, a carbon price is anticipated to help the green development target. However, after the fifth year, it will be unable to do anything to lessen carbon emissions' harm to the ecosystem. There will have been too much of a change in the climate for it not to be the case. A spike in carbon harm could result from a failure to invest in renewable energy, which poses an extra environmental risk.

Ultimately, a rise in the demand for nuclear energy and other energy sources will probably lead to reduced carbon emissions. This decline will happen gradually but visibly. Because of its favourable effects on the local ecology, nuclear power has the potential to become a crucial energy source that contributes to keeping the world average temperature below 1.5 degrees Celsius in the future. This would be helpful given that global temperatures are rising.

Table 6: Matrix estimates of the Innovation accounting

Impulse Response Function of the CDAM					
Period	**CDAM**	**ACFT**	**ANE**	**CPRICE**	**REC**
1	1.149052	1	1	1	1
2	1.129959	1.004878	−1.010029	1.004269	−1.007112
3	1.107168	1.007199	−1.017983	−1.005501	1.003709
4	1.090108	1.008845	−1.023956	−1.003794	1.005621
5	1.073404	1.010809	−1.026256	1.001396	1.010526
6	1.061068	1.012144	−1.026543	1.005806	1.013152
7	1.051053	1.013141	−1.025679	1.009404	1.015209
8	1.043269	1.013753	−1.024252	1.011911	1.016378
9	1.037082	1.014071	−1.022558	1.013592	1.016991
10	1.032157	1.014142	−1.020768	1.014608	1.017156

Table 7: The Variance Decomposition Analysis of the CDAM

Period	**CDAM**	**ACFT**	**ANE**	**CPRICE**	**REC**
1	101	1	1	1	1
2	98.50858	1.060519	1.255881	1.046344	1.128673
3	99.80418	1.147641	1.827905	1.094651	1.125616
4	98.81693	1.256254	2.662324	1.104719	1.159792
5	97.63918	1.407989	3.543516	1.097689	1.311622
6	96.37689	1.587868	4.362899	1.138504	1.533852
7	95.07075	1.788978	5.074713	1.249634	1.815941

8	93.78001	2.000688	5.669397	1.4218412	2.128073
9	92.54288	2.214891	6.153421	1.637941	2.450882
10	91.38738	2.424856	6.539709	1.879297	2.768749

Table 7 shows VDA's estimates that non-conventional and nuclear energy sources will become more significant in the overall energy mix over the next ten years, eventually surpassing the contribution of fossil fuels to global carbon emissions. In the second period, nuclear power produced 1.256% of all energy; by the sixth period, that proportion had risen to 4.363%; and by the ninth period, it was anticipated that nuclear power would produce 6.154% of all energy. In the second period, electricity produced solely from nuclear power plants and renewable energy sources accounted for 1.129% of the variance error shock. From 1.61% in the sixth period to 2.76% in the tenth, this percentage has steadily risen during the study. The damage brought on by emissions related to carbon will start to be lessened after a variance error shock of 1.878% in period ten. Overall, the results emphasize integrating nuclear power with other energy sources, reducing carbon-related consequences, and developing the global energy infrastructure to increase energy efficiency and decarburization.

5.0 DISCUSSION

Governments must dramatically reduce their carbon emissions to abide by international agreements like the Kyoto Protocol and the Paris Agreement-conference of all parties to keep global average temperatures below 1.5 degrees Celsius (COP-26). Developing alternative fuels and technologies, taxing carbon emissions, and supporting renewable energy are the three pillars of sensible environmental policy to combat climate change (Ren et al., 2020). This study aims to evaluate the effectiveness of policies promoted by international organizations to reduce carbon emissions and maintain the world's average temperature. The influence of carbon pricing, carbon emission caps, and the availability of clean fuel and technology on the price of carbon emissions is calculated in this analysis using data collected from five different island economies between 2000 and 2020.

According to quantile regression estimations, nuclear and alternative energy, clean fuel availability, and carbon pricing positively impact the distribution of carbon damages. This result was drawn after examining the connections between these parameters and the quantiles (Rugani & Caro, 2020). Although renewable energy's overall market share is increasing, it is not doing anything to cut carbon emissions. We need to use more renewable energy to achieve the objective of reducing carbon emissions if we are to build energy-efficient infrastructure. We found that the price of carbon is favourably connected with the uptake of renewable energy sources and negatively correlated with the harmful consequences of carbon emissions, filthy fuel, and technology using the Granger causality method. The worldwide adoption of a carbon price has increased interest in renewable energy, infrastructure, and fuels. Humanity can lessen its impact on climate change by using clean fuel technology to support renewable energy production. IRF discovered that using nuclear power, alternative energy sources and a carbon tax will help us reach our decarburization goal. Wang & Zhang (2021), the United Nations and the rest of the world need to proceed with the utmost prudence as they create plans for a future with more sustainable energy. With potential adverse effects on society and the environment, nuclear power should not be regarded as a viable alternative for a green energy source.

6.0 CONCLUSION AND RECOMMENDATIONS

it is hoped that a more significant proportion of renewable sources will make up the conventional energy mix. However, it is anticipated that the adverse effects of carbon emissions will worsen, fewer people will have access to clean energy, and this proportion will be lower than it should be. Developing technology for cleaner fuel while satisfying all safety requirements is one strategy to reduce pollution, which is necessary for the environment's long-term health. The islands' economies must look for technologically supported growth opportunities to move closer to shared prosperity. Moreover, they should be mindful of the long-term strategies that guarantee their achievement. Nuclear power is safer, cleaner, and more effective than other energy sources like hydropower and wind power. It also has a decreased danger of catastrophic disasters, positively impacting society and the environment. These advantages are brought about by nuclear fission as opposed to nuclear energy produced using fossil fuels. The energy sector's public-private partnerships enable essential monetary investments in nuclear power production. One way to accomplish this is through building supply chains that are more environmentally friendly.

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