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Analysing the sustainability of renewable energy in France

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ABSTRACT

In the study fifty seven years of time series data (1965 – 2021) was analysed to check the sustainability of renewable energy both in short run and long run using ARDL model as the data was stationary at the combination of I(0) and I(1). The results showed that CO₂ emission negative relation with renewable energy. As CO₂ emissions reduces with the increasing use of renewable energy. Renewable energy also has a very significant impact on agricultural as the electricity used for agricultural activity is more sustainable. The usage of renewable energy promotes green economy whereas, economic growth encourages environmental sustainability. However the waste and E-waste management needs to be promoted as nuclear energy has a highly radioactive waste materials which needs to be disposed properly as if it is leaked it will not only effect the country but also the neighbouring countries.

Key words: ARDL, Renewable energy, Nuclear energy, Sustainable development, Economic growth

Introduction

In Scandinavian nations, increasing emissions is directly proportional to population and income while persisting at high levels. Due to the direct relationship between total energy consumed and CO₂ emissions, the amount of energy used per person has a high correlation with per capita income. Due to their immediate negative health effects and the relatively small areas they pollute, governments appear eager to reduce SO₂ and NO_x emissions; nevertheless, they gradually reduce CO₂ emissions, mainly during phases of high economic growth. Until recently, developed countries accounted for the majority of human-caused GHGs emissions. But now the percentage of emissions from the emerging economy has also grown dramatically and is estimated to increase more in future. Several researchers believe that one of the primary factors contributing to the expansion of greenhouse gases, which are responsible for cli-

matic instability and global warming is the increase in CO₂ emissions. A group of affluent nations devised the Kyoto Protocol in response to the danger that climate change posed to the environment worldwide. The largest international undertaking in terms of politics and geography is the Climate Change Framework Convention and Kyoto Protocol, which support national policies and actions to mitigate climate change. Under the rules of the Protocol, which came into force in February 2005, the industrialised countries (as a group) vowed to reduce their national emissions over the first commitment period of 2008–2012 by around 5% compared to the year 1990.

Even though France, Canada, Italy, Japan, Germany, the United Kingdom, the Russian Federation, and the United States have taken steps to tackle climate change, the G8 Gleneagles Action Plan was presented in July 2005 to promote sustainable development. Since the signing of the Kyoto Protocol and

the debates that followed, the topic of how carbon dioxide emissions relate to economic development has been a contentious one. The research tries to analyse the short run and long run relation of Renewable energy Vs CO₂ emission and Renewable energy and Agricultural activity. The study also checks the causal linkage between the variables.

Literature Review

The vast majority of research indicates that while economic growth does increase energy use, it does not result in a long-term reduction in carbon emissions. In order to provide guidance for the sustainable development of a region or a country, some academics employ econometric models to investigate the short- and long-term dynamic interactions between elements including carbon release, financial growth, suburbanization, and international trade. The environmental Kuznets curve (EKC) hypothesis demonstrates the relationship between environmental pollutants like CO₂ and GDP as an inverted U-shaped curve (Jebli *et al.*, 2016; Leal and Marques, 2020, Rafiq *et al.*, 2016; Dong *et al.*, 2017; Shahbaz *et al.*, 2019). Numerous studies have examined the causative relationship and unidirectional linkage between energy, GDP, and CO₂ emissions utilising the most recent econometric techniques including ARDL, Wavelet coherence, and Fourier Toda-Yamamoto (Yang and Zhao, 2014; Adebayo *et al.*, 2020; Adebayo *et al.*, 2021; Khobai and Roux, 2017; Faisa *et al.*, 2016; Jafari *et al.*, 2015; Wang *et al.*, 2019; Aydođan and Vardar. 2020, Kirikkaleli *et al.*, 2020, Kirikkaleli and Adebayo, 2021; Al-Mulali, 2011; Wu *et al.*, 2022; AdebayoTS. 2020; Gao and Zhang, 2021. A study that used life cycle analysis (LCA) to examine the effects of ethanol and biodiesel in Latin America found a 70% reduction in greenhouse gas emissions when biofuels are used instead of fossil fuels and recommended turning 5% of pastureland into energy crops to increase biofuel production for low carbon emissions and significant economic benefit Canabarro *et al.*, 2023. Based on bibliometric research, the economic potential of biofuels was examined from 2001 to 2022. The findings showed that the US, China, India, and Europe are the largest biofuel markets, but many sustainable biofuel markets still lag behind those of underdeveloped and emerging nations Hasan *et al.*, 2023. A study recommended creating microbial cell factories to increase the production of biofuel Maurya *et al.*, 2023. Researchers looked at 31 developing na-

tions with poor clean energy production and discovered a negative correlation between GDP and CO₂ emissions Aye *et al.*, 2017, while only a few research revealed a positive correlation between GDP and CO₂ emissions (Teng *et al.*, 2021; Ahmed *et al.*, 2019; Ahmed *et al.*, 2020; Odugbesan and Adebayo, 2020; Pablo *et al.*, 2016; Wasti *et al.*, 2020. Using the Fourier ARDL, Fourier bootstrap Toda-Yamamoto, and wavelet coherence techniques, the EKC hypothesis on time series data for the three major countries of the USA, France, and Japan was examined from 1965 to 2020. This analysis revealed that France reached the breakeven point in 1978, which showed CO₂ decreases with increasing use of nuclear energy, while the South Asian EKC hypothesis was also validated, reflecting a positive impact of using LPG on the environment Singh *et al.*, 2023 and Murshed, 2021.

Methodology

To conduct the study, we used secondary data from the World Bank Development Indicators (WDI) to test our assumptions and accomplish our objective. Equation 1 was created to analyse the relationship between CO₂ emissions, GDP, renewable energy usage (RE), Agricultural production (AP) of the France from 1965 to 2021.

$$\ln \text{CO}_2 = f(\ln \text{GDP}, \ln \text{AP}, \ln \text{RE}) \quad \dots (1)$$

Here, ln is the natural log in the equation above, and Table 1 defines the variable description has definitions of the variables.

$$\Delta \ln \text{CO}_t = a_0 + \sum_{i=1}^{n1} a_{1i} \Delta \ln \text{GDP}_{t-i} + \sum_{i=1}^{n2} a_{2i} \Delta \text{AP}_{t-i} + \sum_{i=1}^{n3} a_{3i} \Delta \ln \text{RE}_{t-i} + \beta_1 \ln \text{GDP}_{t-1} + \beta_2 \ln \text{AP}_{t-1} + \beta_3 \ln \text{RE}_{t-1} + \mu_t \dots (2)$$

The letters a1 to a3 in the equation above reflect the short-run relationship, b1 to b3 represent the long-run relationship, and a0 the drift component. While ni is the optimal lag and t is the error term.

$$\Delta \ln \text{CO}_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i} \Delta \ln \text{GDP}_{t-i} + \sum_{i=1}^{n2} \beta_{2i} \Delta \ln \text{AP}_{t-i} + \sum_{i=1}^{n3} \beta_{3i} \Delta \ln \text{RE}_{t-i} + \theta \text{ECM}_{t-1} + \mu_a \quad \dots (3)$$

In the equation above, the letters a1 to a4 stand for the short-run relationship, b1 to b4 for the long-run connection, and a0 for the drift element. While t is the error term and ni is the ideal lag.

Results and Discussion

The stationarity at level and first difference was in-

investigated using the Augmented Dickey Fuller (ADF) test. It is applied to time series in order to assess the order of the variables' integration. Table 1 (ADF) summarises the augmented Dickey-Fuller's results. The outcomes demonstrated that the dependent variable and the independent variables were all stationary at level and first difference.

Table 1. ADF unit root test

Variables	I(0) t-stats	I(0) p-value	I(1) t-stats	I(1) p- value
CO2	-2.229	0.4664	-6.011	0.003***
GDP	-3.266	0.08*	-5.77	0.0001***
RE	-2.47	0.338	-5.5	0.01***
AP	-2.228	0.456	-4.56	0.02***

***, ** & *denotes 1%, 5% & 10% significance level.

The long-term relationship between the dependent and independent variables is assessed using the Auto Regressive Distributed Lag bond (ARDL) bound test. The upper bound and lower bound are two critical variables that the test displays. The lower bound assumes that all the variables are equal, while the upper limit assumes that there is a first difference for all of them in this situation. The null hypothesis is rejected and co-integration is shown to exist if the upper limit value is less than the F statistic. Table 2 indicates the results of ARDL bound test, the value of F statistics (11.47903) is much greater than the upper bound statistic indicating the existence of significant co-integration between the dependent and the independent variable.

Table 2. ARDL bound test

Variables	F-Statistics		
F (CO ₂ , GDP, RE, AP)	11.47903**		
Critical Value	1%	5%	10%
Lower Bound	3.65	2.79	2.37
Upper Bound	4.66	3.67	3.2

***, ** & *denotes 1%, 5% & 10% significance level.

Table 3 illustrates the results of short run ARDL test whereby RE and GDP are significant at 1% and are negatively related whereas AP is significant at 5% and also has a negative relationship with the CO₂ emission which is favourable for environmental sustainability.

To ascertain whether or not the residuals are regularly distributed, the Jarque-Bera test was used. Given that the Jarque Bera probability is 0.66 (0.05),

Table 3. ARDL short run

Variables	P-value	t-Statistics	Coefficients
RE	0.0001***	-4.457	-0.43
AP	0.0597**	-2.41	-2.93
GDP	0.0004***	-3.8	-0.296

***, ** & *denotes 1%, 5% & 10% significance level

it is likely that the residuals have a distribution that is normally distributed. To check the model for specification issues, the Ramsey RESET test was used. According to the Ramsey RESET test probability of 0.318 (>0.05), the model is free of specification mistakes. The Breusch-Godfrey serial correlation test was performed to determine whether or not there is serial correlation among the error components in our model. The Breusch-Godfrey serial Correlation test probability of 0.122 (>0.05) shows that there is no serial correlation among the error components in our model.

Table 4. Diagnostic tests

JB Normality Test	2.02	0.66
Ramsey RESET test	10.25	0.318
Breusch-Godfery serial Correlation	16.68	0.122
Heteroskedasticity B.P.G. test,	5.46	0.325
Observed R-squared		

The Granger causality test results are shown in Table 5. To determine whether there is any predictability between one variable and another, the test is run on a time series of data. The outcome suggests that RE-CO₂, GDP-CO₂, CO₂-GDP, and CO₂-RE have an unusual unidirectional causal relationship whereas, CO₂-AP has a unidirectional causal linkage.

Table 5. Granger causality test

Direction of Causality	F-stats	Pvalue
RE-CO ₂	5.1	0.096*
AP-CO ₂	9.13	0.0004***
CO ₂ -AP	3.78	0.0596**
GDP-CO ₂	7.9	0.0011***
CO ₂ -GDP	9.7	0.0003***
CO ₂ -RE	4.8	0.0123***

***, ** & *denotes 1%, 5% & 10% significance level.

Cumulative sum of the recursive residuals stability test was employed to check the stability of the model and as the statistics are between the critical

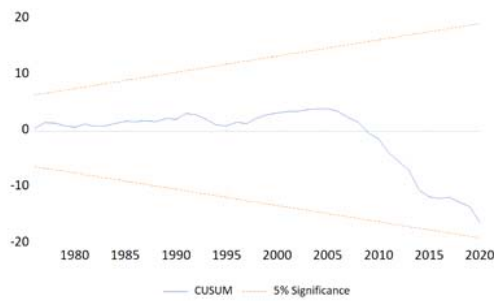


Fig. 1. CUSUM test

bounds as shown in the Fig. 1 ensures the stability of the parameter.

Conclusion

There is a significant relationships between CO₂ emissions, energy consumption and economic growth of France. It has a wide range of options for defining its specific energy strategy concerning to sustainable and renewable energy sources that environmentally sustainable and is also for long-term. That would enable them to change their energy methods reducing environmental harm while steadily and consistently increasing the energy supply over time. By encouraging the development and wide-spread use of alternative and renewable energy technology it may also significantly contribute to ensuring that the environment that is left to future generations in a more habitable and clean state. However the waste and E-waste management needs to be promoted as nuclear energy has a highly radioactive waste materials which needs to be disposed properly as if it is leaked it will not only effect the country but also the neighbouring countries.

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