Clean energy consumption, economic growth, and environmental sustainability: What is the role of economic policy uncertainty?

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Abstract

Undoubtedly, energy is indispensable to attain economic development; however, it also generates CO2 emissions, which are the dominant contributor to environmental deterioration and climate change. In this regard, clean energy can help to achieve both sustainable development and environmental sustainability since it comprises non-carbohydrate energy sources that do not or seldom generate emissions. Against this backdrop, this work considers economic policy uncertainty (EPU) and probes the impact of clean energy consumption on CO2 emissions in the third largest European economy France from 1987 to 2019 controlling urbanization and economic growth. Using the STIRPAT framework, the study employed the novel Augmented ARDL method that overcomes the limitations of the ARDL methods. The outcomes disclosed strong evidence of cointegration as F-statistics (overall and independent variables) and t-statistics of the dependent variables were significant. The long-run analysis revealed that EPU poses a threat to environmental sustainability by augmenting emissions levels. Surprisingly, clean energy consumption does not contribute to emissions reduction in the long-run. Economic growth boosts CO2 emissions, while urbanization is conducive to environmental quality supporting ecological modernization theory. The study detected causality from EPU to economic growth and emissions. Finally, based on the study outcomes, a policy framework is suggested to address the objectives of Sustainable Development Goal (SDG) 7 and 13.

Keywords: Economic Policy Uncertainty; Clean Energy Consumption; Economic Growth; Environmental Sustainability

1. Introduction

Rising level of emission is gradually turning out to be a global concern for the policymakers. The global consumption pattern, energy-led economic growth trajectory, and depletion of natural resources are creating a predicament in maintaining the intergenerational equity. Hence, the foundation of the sustainable development is harmed. In order to tackle this global concern, the United Nations have introduced the Sustainable Development Goals (SDGs), according to which the nations around the world will need to comply with the 17 developmental agendas by the end of 2030. The SDGs are targeted at restoring the global balance by realigning the prevailing economic growth trajectory. Out of the 17 developmental agendas, the SDG 13 needs special attention, as this goal deals with the climate action. With the rise in the population and the industrial activities, the demand for commercial energy is also rising. As fossil fuel is the predominant source of the commercial energy, burning of the fossil fuels is aggravating the climatic issue by increasing the amount of ambient aur pollution (Balsalobre-Lorente et al., 2021; Cheng et al., 2021). Therefore, the compliance with the SDG 13 necessarily entails the attainment of SDG 7, which deals with the clean and affordable energy solutions. Hence, it can be assumed that tackling the ongoing climatic issues will necessitate the development and discovery of cleaner energy solutions. This argument builds the basic premise of the present study.

Now, discussion on climatic issues and mitigation strategies certainly involves the discussion on the *Paris Climate Change Agreement*. It clearly shows the crucial role being played by France in restoring climatic balance, following the withdrawal of the United States from the COP-21. However, among the European and other developed nations, the position of France is comparatively weak in handling the climatic shift issues. During the G7 Presidency of *Climate and Clean Air Coalition* in 2019, France highlighted its failure in handling the climate change issues. Though the air quality policies of France comply with the European Union directives, they are proving to be ineffective (CCAC, 2021). This surfaced during the parliamentary debate on the energy bill, which aimed at net zero emissions by 2050 (E&T, 2019). The environmental protection measures were also encountered by the *Yellow Vest* protest movement, which was targeted at the negative socio-economic consequences of the policy measures. This created an environment of policy uncertainty in the pro-environmental policy fora for France (Clercq, 2019). In theoretical terms, the policy uncertainty has been conceptualized by Baker et al. (2016). An upsurge in policy uncertainty can divert the focus of policymakers to other immediate issues than environmental sustainability (Jiang et al., 2019). This can adversely impact environmental regulations and environmental outcomes. Besides, it is reasonable for industries to expect relaxed ecological regulation, when policy uncertainty levels are very high leading to more focus on economic objectives. The policy uncertainty in France can be seen in Figure 1. In such a situation, attainment of the objectives of SDG 13 might be difficult for the French policymakers as the environmental policy measures largely missed the aspect of inclusivity.

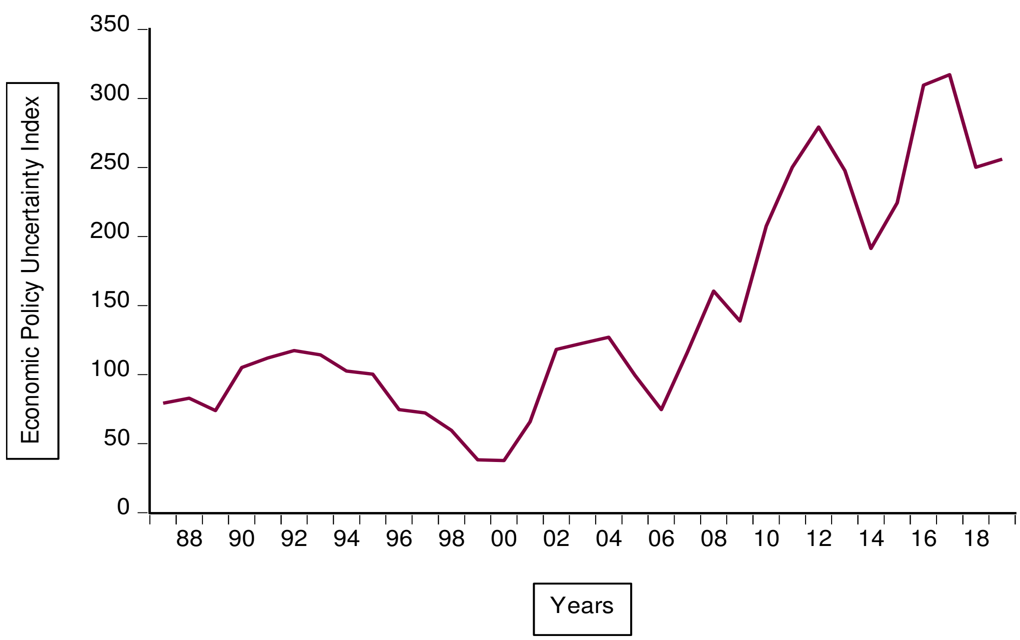

Figure 1: Trend of Economic Policy Uncertainty in France

This environment of uncertainty was complemented by the nuclear plant explosion in Fukushima, Japan in 2011, and the surge in the cost caused by the delay in building a new plant at the Flamanville site in northern France (Gross, 2021). These two events harmed the nuclear power-led growth trajectory of France, as the safety concerns among the citizens were rising. However, in the face of rising gas prices, the demand for nuclear power is rising, overriding the safety concerns. However, the rising protest from Germany regarding concerns about the nuclear waste is problematizing the financing of nuclear power in the European Union. A section of the French policymakers is of the opinion to shift the energy finances from nuclear power to wind and social powers to achieve the carbon neutrality by 2050. The French policymakers are also of the opinion to reduce the nuclear power generation to half by the end of 2035 (The Local, 2019). Hence, the policy level uncertainty regarding the renewable energy future of France is also visible. This situation might create a roadblock in attaining the objectives of SDG 7.

The implication of these situations is reflected in the recent SDG progress report 2021 for France. The indicators of SDG 7 and 13 show that while the share of renewable energy solutions in the primary energy supply has marginally increased, the carbon dioxide (CO_2) emissions from fossil fuel combustion are rising rapidly. Moreover, the emissions are also embodied in the import portfolio (Sachs et al., 2021). It clearly gives an indication that the prevailing economic growth trajectory of France might not be ecologically sustainable, and in presence of the policy uncertainties, the prevailing policies in France might not be sufficient to attain the SDG objectives. Moreover, the emission profile of France shows that the major share of the CO_2 emissions is arising out of the buildings and transportations, primarily from the urban centers. Hence, while encountering the problem of rising emissions and apportioning renewable energy solutions in the energy mix, France also needs to implement the sustainable urbanization, so that the prevailing French urban regeneration policies can be realigned.

Given this background, it can be assumed that the existing energy and other allied economic and environmental policies in France might not be convergent to attain the SG objectives. The political uncertainty regarding the clean energy future and rising carbon emissions might affect the basis of sustainable development in France. Therefore, a policy-level realignment might be necessary, so that France can attain the SDG objectives. There comes the role of the present study. Within the context of clean energy generation and rising CO_2 emissions, along with the prevailing issues of policy uncertainty and urbanization, this study attempts to develop an SDG-oriented policy framework for France. As the European region is encountering an energy crisis, the case of France might be utilized as a benchmark for the other European nations. Moreover, there are various developed nations, which are also trying to embark on nuclear energy generation, but facing a problem in realigning their existing policies for complementing the energy-led growth trajectory. The policy framework to be developed for France might be used as a baseline approach to design the new policy framework for those nations. The policy framework to be designed in this study primarily focuses on attaining the objectives of SDG 7 and 13, while the framework can be extended to touch upon few of the objectives of SDG 11, which deals with the sustainable cities and communities. This generalized policy level approach has not been attempted in the literature, and there lies the policy-level contribution of the study.

Now, for attaining this policy-level objective, the methodological complementarity needs to be ensured. To attain the research objective, this work adopts the recently developed Augmented ARDL (AARDL) method of Sam et al. (2019). Unlike the traditional ARDL method that relies on overall F-statistics and does not inspect the significance of all required arguments, the AARDL adds an F-test on lagged level of regressors. Hence, the 1(1) level integration, which is a required condition for traditional ARDL models, is not necessary for AARDL estimation. In this technique, the cointegration in the model is checked using the overall F-statistics, the F-statistics for regressors, and t-statistics for the dependent variable (Sam et al., 2019). In addition to offering trustworthiness in deciding cointegration, the AARDL offers advantages, such as countering endogeneity and auto-correlation, handle fractional integration, and applicability for small samples. This way, the methodological complementarity in ensured in the study.

2. Literature Review

Many scholars probed the interlinkage between renewable energy consumption (RNE) and emissions; however, relatively few scholars analyzed the impact of clean energy consumption (CLN) on CO2 emissions. Using novel bootstrap ARDL, Cai et al. (2018) conclude that CLN, CO2, and GDP are not cointegrated in some G7 countries including France, the UK, the US, Canada, and Italy. While in other countries there are different causal directions between CLN and emissions. Danish et al. (2017) used CLN in the model (renewables, nuclear, and hydro), even though they termed it as renewables, and disclosed that CLN is conducive to environmental quality.

Besides, many studies confirm that RNE stimulates environmental sustainability. For example, in the context of Africa, Nathaniel and Iheonu (2019) unfolded that RNE mitigates emissions in the overall panel, while country-specific outcomes indicated negative or insignificant impacts of RNE on emissions levels. Further, the effect of income level was either negative or positive in different nations. Likewise, Nathaniel et al. (2020) concluded that RNE supports ecological sustainability in emerging economies, while urbanization (U) derives ecological degradation. They also suggested that income has either negative or positive effects on ecological degradation in different nations. Many other studies supported these pieces of evidence, for instance, Bilgili et al. (2016) disclosed that RNE subsidizes emissions in OECD nations and Bölük and Mert (2015) unfolded similar findings in Turkey. The study of Jebli and Youssef (2015) documented similar evidence in Tunisia. Studies mostly documented this mitigating impact; however, some differences in results prevail throughout the literature. For example, the study of Mert (2014) highlighted that RNE is conducive to environmental deterioration and Farhani and Shahbaz (2014) also concluded detrimental effects of RNE on emissions. In the context of Vietnam, Al-mulali et al. (2015) conducted a time-series analysis and concluded no significant environmental effect associated with RNE.

In recent years, researches considering EPU in different contexts are increasing. For instance, Balcilar et al. (2017) studied the oil market and EPU nexus, Pastor and Veronesi, (2010) linked EPU with stock prices, while Dibiasi et al. (2018) linked EPU and investments. Demir and Gozgor (2016) unfolded that EPU is negatively linked with travel time in the US. Jiang et al. (2019) is the first study that probed causal association between EPU and CO2 emissions using sectoral data of the US and revealed a causal association between both variables. In a recent study, Adams et al. (2020) investigated the effects of EPU and income on emissions level in resource-rich countries. Their findings unfolded that EPU and income level upsurge emissions levels. In contrast, Syed and Bouri (2021) employed bootstrap ARDL and disclosed that EPU reduces emissions level in the US in the long-run; hence, controlling EPU will not reduce CO2 emissions.

This discussion unfolds that there are very limited research works on EPU and emissions nexus and outcomes are mixed. Overall, it is difficult to conclude whether EPU increases/reduces emissions level because there are very few studies and different effects are reported. Hence, it is important to study this topic in different nations for suitable policies. Besides, although there is very limited literature on clean energy and most of the literature focuses on investigating impacts of REN, it is plausible to expect that CLN will either reduce emissions level or their effect will be insignificant as CLN does not or seldom emit emissions (Cai et al., 2018; Sharma et al., 2021). Further, the effects of CLN and EPU on emissions are unexplored in the context of France.

3. Data and Methodology

3.1. Data and Model

The Integrated Population, Affluence, and Technology model (IPAT) model is extensively used to study the influence of different factors on the environment. However, this model is criticized on the ground that it is an accounting identity that does not allow hypothesis testing. It is also based on a very strict assumption of a proportionate relationship between selected indicators (Sheng and Guo, 2016). Therefore, Dietz and Rosa (1997) have modified this model into the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) form to overcome these weaknesses. The STIRPAT model is articulated as follows.

$$I_t = aP_t^b A_t^c T_t^d \mu_t \quad (1)$$

In this study, the environmental impact (I) is measured by CO2 emissions, affluence (A) is represented by economic growth (G), the population (P) is represented by urbanization (U), and technology (T) is denoted by clean energy consumption (CLN). The elasticities of population, affluence, and technology are denoted by *b*, *c*, and *d*, respectively, while *a* represents the constant term. Following (Ahmed et al., 2019; Paramati et al., 2017; Solarin and Al-Mulali, 2018), this work used urbanization to measure population effect since urban population greatly influence emissions levels, and France has already reached a high level of urbanization. EPU will be an additional factor to the model as this flexible model allows the addition of different variables. According to Syed and Bouri (2021), EPU decreases emissions, while Adams et al. (2020) unfold environmental deterioration associated with EPU. Hence, EPU can affect emissions and it is rational to add EPU in the model. The variables selected for the study are converted into natural logarithm for trustworthy outcomes following Caglar (2020). The long-run form of our model is articulated below.

$$LCO2_t = \varphi_o + \varphi_1 LG_t + \varphi_2 LCLN_t + \varphi_3 LEPU_t + \varphi_4 LU_t + \mu_t \quad (2)$$

In the model, φ_o denotes the intercept term of the model, $\varphi_1, \varphi_2, \varphi_3, \varphi_4$ are the coefficients, and μ_t is the error term. All the model parameters are log-transformed, as denoted by the prefix "L" before all the model parameters..

The period of the study from 1987 to 2019 is linked with data availability on EPU. The study accessed WDI indicators[1] to collect data on economic growth (G) and urbanization (U) which are proxied by GDP 2010 constant US dollars per capita and urban population (% of total population), respectively. For clean energy consumption, British Petroleum (2019) is accessed, and data on clean energy consumption (nuclear, renewables, and hydro) is collected in Exajoules and transformed into per capita. The news-based EPU index of Baker et al. (2016) is used to proxy economic policy uncertainty. EPU monthly data series was converted into annual frequency for the time-series analysis as annual data is available for other variables. We relied on the average method (in Eviews) to transform this data, and it was assured that the data series portrays similar patterns after and before conversion. CO2 emissions (tonnes per capita) data from 1987 to 2019 came from IEA (2020).

3.2.Methodology

In this research, we employed the Augmented ARDL (AARDL) approach of Sam et al. (2019). This technique extends the ARDL technique of Pesaran et al. (2001). Before application

[1] https://databank.worldbank.org/home.aspx (Accessed January, 2021)

of the AARDL test, we probed integration level and confirmed that analyzed variables are stationary either at 1(1) or/and 1(0) since variables with order 2 integration cannot be accommodated to the model even in the AARDL approach. Following Sam et al. (2019) and Pata and Caglar (2020), we adopted unit root methods without structural breaks as well as the Zivot-Andrew (ZA) test that identifies one break in the analyzed variables.

The work of McNown et al. (2018) pointed out the limitations of the ARDL bound test and suggested that cointegration in a model should be tested using three tests instead of relying on overall F-statistics. Further, the study of Cai et al. (2018) suggested that relying on traditional bound test leads to unreliable findings. Hence, this study adopted the AARDL approach of Sam et al. (2019) that introduces an F test on the lagged level of regressors and accounts for degenerate cases. The model for the study can be re-written as follows.

$$\begin{aligned}\Delta(LCO)_t = \gamma_o + \varphi_1 DU_t + \sum_{k=1}^{p}\varphi_{1k}\Delta(LCO2)_{t\text{-}k} + \sum_{k=0}^{p}\varphi_{2k}\Delta(LG)_{t\text{-}k} + \sum_{k=0}^{p}\varphi_{3k}\Delta(LEPU)_{t\text{-}k} + \sum_{k=0}^{p}\varphi_{4k}\Delta(LCLN)_{t\text{-}k} \\ + \sum_{k=0}^{p}\varphi_{5k}\Delta(LU)_{t\text{-}k} + \gamma_1(LCO2)_{t\text{-}1} + \gamma_2(LG)_{t\text{-}1} + \gamma_3(LEPU)_{t\text{-}1} + \gamma_4(LCLN)_{t\text{-}1} + \gamma_5(LU)_{t\text{-}1} + \mu_t\end{aligned} \quad (3)$$

In equation 3, first, the short-run part is articulated (φ_1 to φ_5) followed by the long-run part from γ_1 to γ_5. DU denotes the dummy variables for the break that exists in CO2, and μ_t symbolizes residual term. γ_0 represents the intercept term of the equation. The traditional ARDL model inspects the following hypothesis for cointegration

$$H_0{:}\, \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0 \qquad (4)$$

The rejection of the above hypothesis through the F test implies cointegration under the ARDL framework (Pesaran et al., 2001). However, there are many limitations to this approach. The combined significance of coefficients does not necessarily mean cointegration because it can be associated with the significance of either independent or dependent variables. To overcome this issue, Sam et al. (2019) proposed a t-test for the lagged dependent variable, while McNown et al. (2018) developed an F test for the lagged level of regressors. The hypotheses for these tests are as follows.

$$H_0: \gamma_1 = 0 \quad (5)$$

$$H_0: \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0 \quad (6)$$

The critical values for the overall F-test and dependent variable's t-test are acquired from Narayan (2005) and Pesaran et al. (2001), respectively, while Sam et al. (2019) provide bootstrap critical values for F-test on regressors. The hypotheses given in equations 4, 5, and 6 must be rejected for cointegration (Sam et al., 2019). However, the authors also illustrate some degenerate cases showing incorrect cointegration. First, the F tests (overall and independent variables) are significant but the t-test for the dependent variable is insignificant. Second, F-test for regressors is insignificant but the other two tests are significant. The AARDL method used in this work not only solves all these degenerate cases but also eliminates the strict assumption for the ARDL model that requires 1(1) stationary level for the dependent variable. Alongside this, it also resolves the endogeneity issue and allows more than one endogenous variable in the model (Pata and Caglar, 2020). Besides, the benefits to accommodate fractional integration and better performance for small sample makes the AARL a reliable method for time-series analysis.

In the final step, this work uses the Toda and Yamamoto (TY) method of causality which is suitable for this paper due to many reasons. Similar to the AARDL, the TY test is flexible to include variables with various integration levels. This method can be adopted regardless of long-run equilibrium relationship and even unit root testing is not necessary for its application (Jawad et al., 2017). At times, cointegration and unit root methodologies can be biased but the TY test addresses this issue due to its flexibility (Ahmed et al., 2019).

4. Results and Discussion

Before moving to the analysis, descriptive statistics are computed and presented in Table 1. After this, the analysis is initiated by using some unit root tests to make sure that the empirical analysis does not produce spurious results.

Table: 1
Descriptive Statistics

	LCO2	LG	LEPU	LCLN	LU
Mean	1.70210	10.5376	4.8083	-16.4314	4.3411
Median	1.7532	10.5709	4.7552	-16.4139	4.3390
Maximum	1.8445	10.6991	5.7593	-16.3290	4.3908
Minimum	1.4695	10.2882	3.627093	-16.6449	4.3014
Std. Dev.	0.1111	0.115265	0.576013	0.083255	0.028352

In Table 2, the estimates generated from the PP and ADF test illustrate that except CLN, all other variables are non-stationary at level. Hence, CLN is I(0), while the other variables are I(1). This difference in the order of integration is tackled by the AARDL method. However, before applying the AARDL, Sam et al. (2019) and Pata and Caglar (2020) used the structural break unit root test accounting for one unknown break. Therefore, following previous literature, ZA test is employed. The empirical estimates in Table 4 generated quite different outcomes. EPU and urbanization are at I(0), while CLN, G, and CO2 are at I(1).

Table: 2
PP and ADF tests

Variables	**Phillips–Perron (PP)**	**Augmented Dickey-Fuller (ADF)**

	Levels	Difference	Levels	Difference
	T-Stats	T-Stats	T-Stats	T-Stats
LCO2	1.0592	-6.4066[a]	0.3953	-6.4066[a]
LG	-2.3683	-3.9253[a]	-2.6033	-3.9948[a]
LEPU	-1.1402	-4.0846[a]	-1.0296	-4.5480[a]
LCLN	-2.8228[c]	-5.3076[a]	-2.8344[c]	-5.2587[a]
LU	4.0454	-3.4915[b]	1.5371	-3.5173[b]

Note: [a], [b] and [c] denote 1%, 5%, and 10% significance.

Table: 3
ZA Test

	Levels		Difference	
Variables	T-Stat	Break Year	T-stat	Break Year
LCO2	-4.2879	1998	-8.0222[a]	1995
LG	-3.9910	1998	-5.0138[c]	2008
LEPU	-4.8913[c]	1998	-6.1928[a]	2001
LCLN	-3.4479	1996	-7.1571[a]	1994
LU	-8.3262[a]	1998	-7.5571[a]	2000

Note: [a] and [c] show 1% and 5% significance.
Critical Values are: -4.82, -5.08, and -5.57 at 1%, 5%, and 10% significance.

The ZA test suggests a break in CO2 in 1995, which can be traced back to the economic downturn of the Europe during the early recession of the 1990s. This recession can have negative effects on the CO2 emissions level in France through slump in economic growth. Consistent with Sam et al. (2019), this paper also introduced a dummy variable for the break in CO2. Similar to this break, the break in CLN can also be related to this event, while the break in G is connected with the 2007-2008 financial crises. These outcomes also supported the assumption of fractional integration in the series.

Table: 4
AARDL Test for Cointegration

Model selected	AIC Lag order	B. Year	$F_{overall}$	F_{IDV}	t_{DV}	Decision
LCO2|LG, LEPU, LCLN, LU	1 0 1 2 1	1995	9.4860[a]	11.8489[a]	-6.5896[a]	Cointegration
Critical Values	%1	%5	%10	Source		
$F_{overall}$	6.368	4.63	3.898	Narayan (2005)		
F_{IDV}	6.63	4.67	3.82	Sam et al. (2019)		
t_{DV}	-4.6	-3.99	-3.66	Pesaran et al. (2001)		
Diagnostic Tests	Results					
R-Square	0.9778					
Adjusted R-Square	0.9667					
Normality-JB	2.6032 [0.2721]]					
F-statistics	88.0822 [0000]					
DW Stat	2.2507					
$\chi2$ ARCH	0.0051 [0.9409]]					
$\chi2$ RESET	0.0047 [0.9461]					
$\chi2$ LM	1.2327 [0.2807]					
CUSUM	Stable					
CUSUMSQ	Stable					

Note: Critical values are obtained for Case III (unrestricted intercepts; no trends)
P-values are given in brackets.
[a] indicates 1% significance

The outcomes from the AARDL method are reported in Table 4. The significance of the F statistics signifies the presence of cointegration in the model. The diagnostic tests unfold that the model is free from residual auto-correlation, misspecification, heteroscedasticity, and endogeneity issues. Additionally, residuals have a normal distribution and both CUSUM and CUSUMSQ

(Figure 2 and 3) are stable. As the obligatory condition for the long-run association is met, estimation of long-run elasticities using Eq. 3 can be carried out.

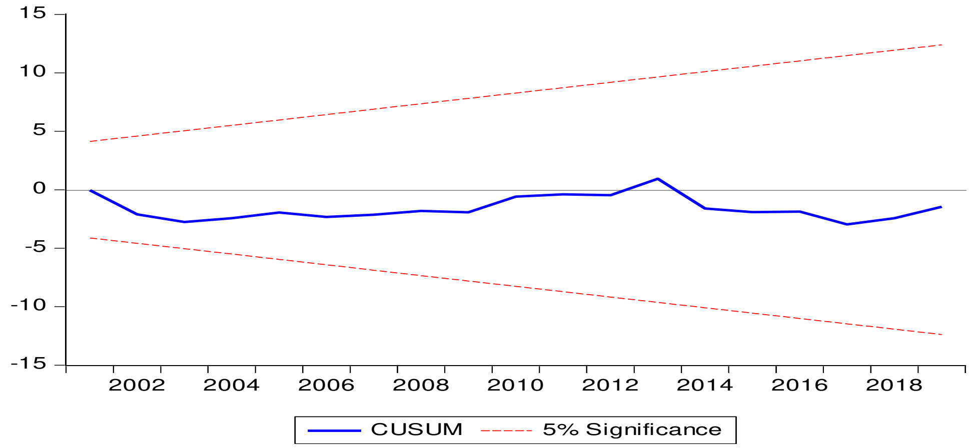

Figure 2: CUSUM

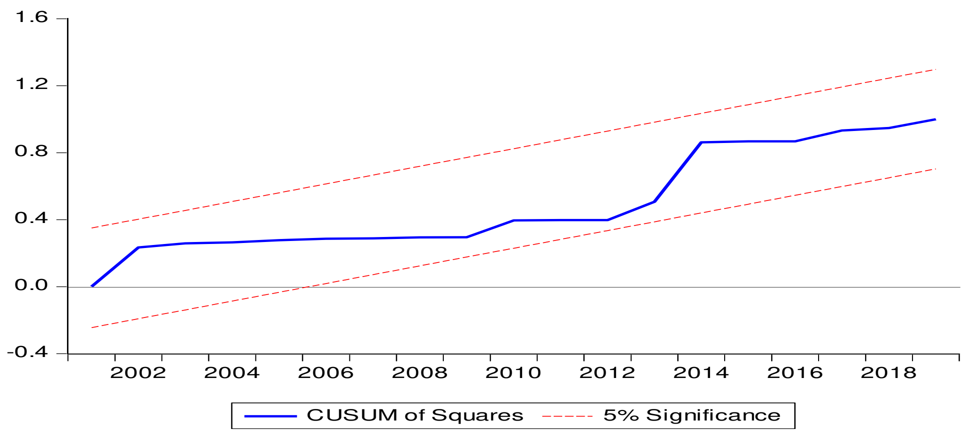

Figure 3: CUSUMSQ

The findings summarized in Table 5 illustrate that economic growth (G) intensifies emissions in France. A 1 percent rise in G results in a 1.25 percent increase in CO_2 emissions, demonstrating that economic expansion in France is attained at the cost of environmental quality. This finding does not corroborate the claims of Rasool et al. (2019) for Pakistan and Nathaniel and Iheonu (2019) for Africa. However, this unfavorable role of G in environmental quality is in consonance with Umar et al. (2020) for China, Zafar et al. (2020) for Asian countries, Doğan et al. (2020) for developed nations, and Zameer et al. (2020) for India. Shahbaz and Sinha (2019) have given a detailed account of this association. It gives a clear indication that treading on this prevailing economic growth trajectory might deter France to attain the SDG objectives.

Table: 5
Long-run & Short-run Estimates

Long-run				Short-run			
Variables	Coeff.	T-Stat	Prob.	Variables	Coeff.	T-Stat	Prob.
LG	1.2479[a]	5.9152	0.0000	LG	0.0547	0.3887	0.7016
LEPU	0.0342[b]	2.4086	0.0258	LEPU	-0.0111	-0.5449	0.5919
LCLN	-0.0463	-0.5226	0.6070	LCLN	-0.4253[b]	-2.3339	0.0302
LU	-9.4027[a]	-11.7572	0.0000	LURB	-4.2425	-0.2335	0.8178
DU	-0.0306	-1.6454	0.1155	DU	-0.0363[c]	-1.8362	0.0812
				C	26.1023[a]	4.1326	0.0005
				cointEq(-1)	-0.9377[a]	-3.8945	0.0009

Note: [a],[b], and [c] show significance at 1%, 5%, and 10%.

Usually, the adverse effects of G are mitigated using clean energy; however, the coefficient of CLN in Table 5 unfolds that the effect of CLN is negative but insignificant. This segment of the findings complements the impact of economic growth on CO2 emissions, showing the ecological unsustainability of the energy-led growth pattern. This verdict contradicts Danish et al. (2017) for Pakistan, Nathaniel and Iheonu (2019) for Africa, and Sinha and Shahbaz (2018) for India. This evidence is supported by the time-series study of Al-mulali et al. (2015) for Vietnam. This outcome indicates the uncertainty in the renewable energy future in France. This prevailing situation in France is also visible through the insignificant impact of CLN on CO2 emissions. This segment of the findings might be of concern to the policymakers, as it shows the unsustainable energy-led growth trajectory being attained in France. Prevalence of this situation might be a deterrent in attaining the objectives of SDG 7 and 13.

This unsustainability in the energy-led growth might be explained by the presence of uncertainty in the French economic system. The study outcome shows that a 1% raise in EPU intensifies CO_2 emissions by 0.034%. This estimate reveals that EPU in France deteriorates the environment. This outcome opposes the finding of Syed and Bouri (2021) in case if the US, but complies with the work of Adams et al. (2020) for the resource-rich economies. The prevailing political turmoil in the French economy might be restricting the environmental policies to reach their full potential. Moreover, the drift of finances from nuclear to wind and solar energy solutions is also being restricted by this persisting uncertainty. In order to secure a sustainable energy future, this policy-level uncertainty needs to be managed by the policymakers.

Finally, urbanization (U) found to be reducing the CO_2 emissions. This estimate differs from many previous studies (Ahmed et al., 2020b; Al-Mulali and Ozturk, 2015; Sinha et al., 2017; Rashid et al., 2018). However, our claim coincides with the work of Charfeddine and Ben Khediri (2016) and Ahmed and Wang (2019). Moreover, this finding is also supported by the ecological modernization theory that claims urban sustainability linked with high urbanization levels (Poumanyvong and Kaneko, 2010). With the increase in urbanization, resource efficiency and efficient productivity is achieved through economies of scale. In highly urbanized areas, water supply, sanitation, waste management, and other public services are less costly to run and construct. Also, urbanization encourages modernization leading to innovation, energy efficiency, and efficient technology (Ahmed and Wang, 2019; Sinha et al., 2020 a, b). All these reasons contribute to CO_2 mitigation linked with urbanization, and these benefits are reasonable in the context of a developed country France where 80% of the population is urbanized.

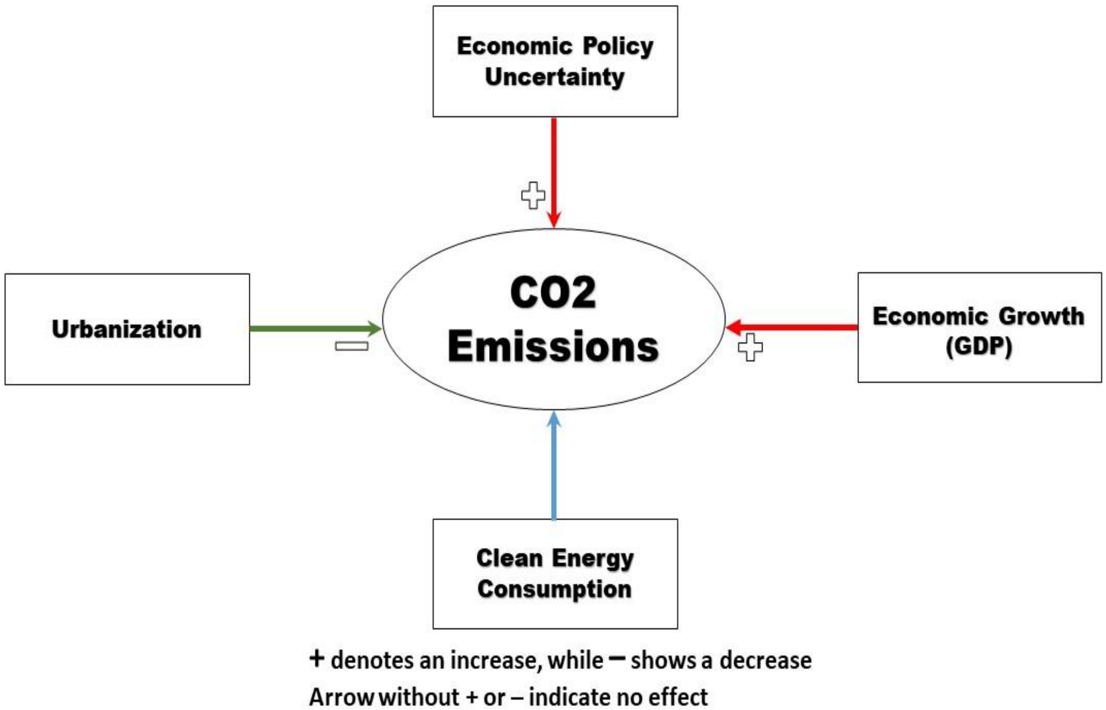

Figure 4: Long-run AARDL result

In the long-run dummy variable (DU) is insignificant; hence, the European recession of 1990s does not affect CO2 emissions in the long-run, but in the short-run, it lessens CO2 emissions. Besides, only CLN promotes environmental quality in the short-run highlighting some short-run benefits of CLN in reducing CO2 emissions. All other variables could not reach significance in the short-run; however, the deviations from equilibrium are adjusted swiftly since lagged ECT is -0.94 representing a convergence period of just over 1 year. Figure 4 depicts the long-run AARDL estimates.

Table 6:
Toda and Yamamoto Causality test

Dep. Variable	LCO2	LG	LEPU	LCLN	LU

LCO2	----	17.0373[a] [0.0007]	7.9299[b] [0.0475]	17.5654[a] [0.0005]	8.0337[b] [0.0453]
LG	7.2260[c] [0.0650]	----	6.6787[c] [0.0829]	4.7919 [0.1877]	12.7546[b] [0.0242]
LEPU	2.2050 [0.5310]	1.9577 [0.5812]	----	5.2383 [0.1552]	0.8837 [0.8294]
LCLN	1.7889 [0.6174]	2.0002 [0.5724]	1.3449 [0.7185]	-----	3.1084 [0.3752]
LU	7.3475[c] [0.0616]	12.8954[a] [0.0049]	2.2410 [0.52390]	1.8436 [0.6055]	----

Notes: [a], [b], and [c] represent 1%, 5%, and 10% significance

Following the long-run elasticity estimation, this study applied TY causality test. The causal directions in Table 6 show bidirectional causality causal association between CO2 and G, and between U and CO2. It infers that there is a high interlinkage between the growth of France and CO2 emissions, and it is challenging to reduce emissions level without affecting growth. Secondly, urbanization and emissions are also interlinked implying that U mitigates CO2, and to achieve a reduction in CO2 urban sustainability policies are implemented which also affect the urbanization level in France. The causality from EPU and CLN to CO2 is unidirectional. Besides, there is a feedback effect between U and G, which advocates that reducing urbanization can hurt economic growth in France since urbanization is linked with economic development. Finally, causality from EPU to economic growth (G) discloses that an increase in EPU hurts the economic development of France. The presence of the causal associations might be crucial from the perspective of policymaking, as inherent bidirectionality indicates the policy impacts (Sinha et al., 2018).

5. Conclusion and Policy Directions

By far, this work has examined the impacts of EPU and clean energy consumption on CO2 emissions in France between 1987-2019, following the STIRPAT framework. The AARDL estimates unfolded that EPU and economic growth augment CO2 emissions, while clean energy consumption in France does not significantly reduce CO2 emissions. However, urbanization in France is environment friendly and it contributes to environmental sustainability. In causal connections, EPU not only Granger-causes CO2 emissions but also causes economic growth. Urbanization, CO2 emissions, and economic growth have bidirectional causality.

As the political uncertainty in France is causing a rise in the level of CO2 emissions, the first policy initiative to be taken by the policymakers should involve reducing the level of policy uncertainty. This move might entail a discussion between the citizens and the government, so that the prevailing frictions regarding the socio-economic impact of the environmental policies can be reduced. By virtue of the effective communication and bargaining between the parties, the policy optimum can be achieved at the Cournot equilibrium level (Zafar et al., 2019). Once the uncertainty in the political system is reduced, then the shifting of energy finances should be initiated. However, it should be remembered that the shift should not be overnight, as withdrawing the finances from the nuclear power generation might cause serious harm to the persisting economic growth pattern. Hence, the policymakers should gradually start diverting the finances towards the wind and solar energy solutions. This drift will help France in gradually aligning with the political situation regarding energy policies in the European Union. Therefore, the possible policy uncertainties arising out of the international relations might also be mitigated. Once this political uncertainty, both in the domestic and international political environment will be reduced, the environmental policies will start gaining its full potential. In such a scenario, France will be able to make a progress towards the attainment of the SDG 13.

Now, while the political uncertainty is reduced, the energy finances will start to be diverted towards the wind and solar energy solutions. This will gradually reduce the dependence on the nuclear energy solutions, and the environmental quality will start improving with less amount of nuclear waste getting generated. Though initially the energy price will be higher compared to the present market price, but once the renewable energy generation process starts reaching economies of scale, the price is expected to come down (Ahmad et al., 2021). This will ensure that the French citizens can have clean energy solutions at affordable prices. This will help the policymakers in France to attain the objectives of SDG 7.

Now, this brief policy framework has the necessary level of generalizability in terms of its applicability towards other nations. In order to comply with the Agenda 2030, several nations are depending upon the nuclear energy solutions. However, given the safety and the implementation cost issues associated with the nuclear energy generation, the countries might be encountering policy uncertainties, both at the parliamentary and grassroots levels. The policy framework suggested in the study can be utilized as a benchmark approach to address the policy realignment concerns in those nations. The major advantage with this framework is the aspect of flexibility, so that this framework can be adjusted in accordance to the specific feature of the target country. This generalizability has ensured the contribution of the study in the literature of energy economics.

Lastly, it is imperative to mention that the study has considered only four dimensions to assess the behavior of CO_2 emissions in France. This might raise the question of the scope of the policy framework suggested in the study. However, non-inclusion of the other model parameters has given a model a sense of generalizability, so that it can be modified in accordance to the country characteristics. Hence, the apparent limitation of the study has given it the desired aspect of generalizability.

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