THE ENVIRONMENTAL PHILLIPS CURVE: A CROSS-COUNTRY ANALYSIS OF UNEMPLOYMENT AND ENVIRONMENTAL DEGRADATION

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Abstract
The concern about climate change and its impact on human life and economic activity has been steadily increasing in recent years and one big question that keeps coming up in policy discussions is how we can balance a robust economy with protecting our environment. A new idea called the Environmental Phillips Curve (EPC), mainly based on an older economic concept, the Phillips Curve is trying to tackle this challenge. In traditional economic theory, when unemployment goes down, inflation tends to go up, and vice versa. The EPC revises the original interpretation to address environmental concerns. The main idea is that when more people are unemployed, there's less economic activity, which means fewer emissions and less pollution, on the other hand when we try to create more jobs and boost the economy, we might end up hurting the environment in the process. It's like being caught between a rock and a hard place, do we prioritize jobs or the planet? This study attempts to test whether this Environmental Phillips Curve holds true across different European Union countries. To do this, we're using a sophisticated statistical method called cross-sectionally augmented autoregressive distributed lags (CS-ARDL), a tool that helps us analyze complex economic and environmental data patterns across multiple countries over time.

Keywords*: Environmental Phillips Curve, climate change, unemployment, economic growth, ARDL*

1. INTRODUCTION

There is no doubt that the prosperity and welfare achieved by the developed world, especially after the Industrial Revolution, entails a significant cost, that may have been initially overlooked until it grew so large that its negative consequences could no longer be ignored. The impact of human activity on the environment is a matter of constant concern, and rightly

so, as it is now evident that these consequences stand in direct contradiction to the achievements of the modern world and threaten not only its prosperity but also its security. The initial optimism that technological development could address the problem of resource scarcity has gradually given way to deep concern for the very existence of life on the planet. Climate change is nowadays a constant refrain at a scientific and political level, converting climate cost as an important parameter in any serious system of political and economic decision-making.

The main factor of concern is the increase in carbon dioxide (CO_2), which contributes nearly 80% of total greenhouse gas emissions and steadily rises over the last 100 years, making climate actions a urgent priority and to this end governments and international organizations are taking action to reduce emissions (Adamopoulos, 2021; IPCC, 2023; Karsiotis & Adamopoulos, 2025). According to NASA[1] the last 10 years are the warmest years on record and therefore transforming the global economy into a green economy must be our priority. But balancing economic growth with environmental sustainability is a great challenge, especially when taking into account traditional and unsolved economic problems like unemployment.

Can we reduce emissions without sacrificing employment? Although there is no direct link between environmental degradation and employment, there is great concern if the emergence of "green jobs" can contradict losses in carbon-intensive industries. While energy transition threatens job losses in carbon-intensive sectors, it simultaneously creates substantial opportunities in emerging green industries putting pressure on the labor force to adapt to new skills, which requires time and effort. Apart from that new green jobs may not be located where job losses occur as losses are often geographically concentrated, creating regional unemployment.

In economic theory, unemployment and full employment are topics that have preoccupied and will continue to concern economic thinking and political debate. As new challenges and societal priorities emerge economic theory must seek new tools of analysis, to answer old questions in a new framework. Under these circumstances, traditional frameworks, such as the famous Phillips curve, which originally described an inverse relationship between unemployment and inflation, can be adapted and reframed in modern contexts by incorporating additional variables and mechanisms that reflect today's economic reality. The Environmental Phillips Curve (EPC) is an extension of the classical model, which attempts to link unemployment to carbon emissions. If there is empirical evidence of a tradeoff between those two, that is very important information for policymaking.

2. LITERATURE REVIEW

The relationship between economic growth and environmental degradation is well established in the literature, as higher production is associated with higher pollution (Kashem & Rahman, (2020), Azimi & Rahman, (2024)). Additional employment increases as production increases and thereby income increases as well. This concept is not new in economic literature and finds its theoretical background in Okun's law (1962). If production generates employment and production generates pollution, then employment and pollution become indirectly linked through their common source. In such a framework, higher employment typically reflects higher levels of productive activity. The fact that pollution and employment move together does not necessarily mean one causes the other. Empirical evidence should be provided to avoid a spurious regression.

[1] https://climate.nasa.gov/vital-signs/global-temperature/?intent=111

How does unemployment be linked to environmental quality? According to Bhowmik et al., (2022) the connection between those two can be established through two contradicting channels, the "growth channel" and the "preference channel". Increase in unemployment indicates decline in economic growth and reduction in energy consumption, and therefore it is logically expected to decline carbon emissions. The "preference channel" reflects the reluctance of consumers, as unemployment increases and therefore income decreases to purchase improved environmental quality but costly goods. The idea of an inverse relationship between pollution and unemployment equivalent to the traditional Phillips Curve is a relevant new context, initially explored by Kashem and Rahman (2020). By using data from 30 industrialized countries for period 1991 to 2016, they confirmed that these inverse relationships does hold true in most of the cases and according to their findings, fighting environmental pollution without innovation and enforcing alternative technologies to be less polluting but employment friendly, employment could suffer severe reduction. Since then, various studies have confirmed the validity of this hypothesis including different models and techniques.

Anser et al., (2021) affirmed a significant trade-off between unemployment and environmental degradation for BRICST economies (Brazil, Russia, India, China, South Africa, and Turkey) from 1992 to 2016, employing ecological footprint as an environmental indicator and the PMG-ARDL model. Same confirmation with the same model by Tariq et al., (2022) validated the EPC in South Asian countries (Pakistan, India, Bangladesh, and Sri Lanka) from 1991 to 2019, showing that renewable energy and unemployment reduced environmental pollution. Ng et al., (2022) adopted a second-generation panel unit root and cointegration test to account for the presence of cross-section dependence (CSD) for 36 OECD countries between 1995 and 2015 and their findings suggest that investment in innovative green technologies is important for achieving sustainable growth and better environmental quality.

Bhowmik et al. (2022) attempted to distinguish between the long and short run impact by employing a dynamic ARDL model and concluded that EPC is valid in the long run but not in the short run for the USA (1985-2018). Teeli et al., (2025) confirmed the EPC validity for India using annual time series data from 1991 to 2022 and various econometric methods, including the ARDL model. The findings confirm the validity of the EPC in both the long and short run, suggesting that increased employment is associated with higher environmental degradation.

Using an Augmented Autoregressive Distributed Lag (A-ARDL) model with a Fourier term, Yavuz et al., (2023) confirmed a cointegration relationship between LCF and its determinants. The findings indicate that the EPC is valid in Turkey: unemployment improves environmental quality, while gross domestic product, natural resource rents, and primary energy consumption accelerate environmental degradation. The authors conclude that concurrent achievement of employment and environmental policies is difficult, proposing environmentally friendly production methods like renewable energy as a solution to foster both employment and environmental improvement. Daştan et al., (2023) also confirmed both EKC and EPC hypotheses for Turkey, by employing the augmented autoregressive distributed lag (A-ARDL) model and using ecological footprint as a comprehensive environmental indicator. Koyuncu Çakmak et al., (2025) using a novel dynamic ARDL simulation approach and found the EPC valid in upper and lower middle-income countries but not in high-income economies in Turkey (1990-2020).

Azimi and Rahman (2024) investigated the EPC hypothesis in G7 nations from 1990 to 2022 using CS-ARDL, wavelet coherence, and wavelet causality techniques. An inverse relationship between unemployment rate and CO_2 emissions was found and thus validating the EPC hypothesis for the selected sample. As expected, findings suggest that economic growth increases CO_2, while renewable energy and technological innovations mitigate it,

which leads to the conclusion that creative policy solutions to balance CO_2 reduction with employment by implementing green technology and sustainable practices is essential for employment growth and environmental sustainability. Djedaiet, (2023) investigates the asymmetric effects of unemployment and inflation rates on environmental quality in African OPEC countries from 1990 to 2019 by utilizing a panel NARDL model (PMG-NARDL) and confirmed the EPC in the long run. Shastri et al., (2022) included gender in their analysis using time series data and econometric models (ARDL, FMOLS, DOLS) and find that higher male unemployment correlates with lower CO_2 emissions, while no similar relationship exists for women.

3. METHODOLOGY AND DATA ANALYSIS

This study examines the relationship between environmental quality and unemployment through the lens of the Environmental Phillips Curve (EPC), which extends the traditional Phillips curve framework to incorporate ecological dimensions. Following the work of recent environmental economics literature, we model the tradeoff between carbon emissions and labor market outcomes. As already mentioned, the theoretical foundation rests on the hypothesis that stricter environmental regulations and the transition to a low-carbon economy generate both creative destruction effects by simultaneously eliminating jobs in carbon-intensive sectors while creating employment in green industries. Our baseline empirical specification takes the following form:

$$\ln\left(\mathrm{CO2}_{\mathrm{i},t}\right) = \beta_0 + \beta_{1i}\ln\left(\mathrm{GDP}_{\mathrm{i},t}\right) + \beta_{2i}\left(\ln \mathrm{REN}_{i,t}\right) + \beta_{3i}\left(\ln \mathrm{EC}_{i,t}\right) + \beta_{4i}\left(\ln \mathrm{UNM}_{i,t}\right) + \mu_{i,t}$$

The variables of this equation are presented in Table 1.

Table 1-Variables – Summary of data

Variable	Brief description	Unit of Measurement
CO2	Annual CO_2 emissions from agriculture, energy, waste and industry (excluding LULUCF).	Mt CO_2e (Million tonnes of CO_2 equivalent)
UNM	Unemployment	% of total labor force
REN	The share of electricity generated from renewable sources.	% of total electricity production
GDP	The total income from the production of goods and services.	Current US Dollars ($)
EC	Primary energy use per unit of GDP.	kg of oil equivalent per $1,000 GDP

In this study, a comprehensive study is conducted to explore the determinants of ecological footprint for the 7 European countries (Spain, Netherlands, Italy, Greece, Latvia, Germany, Finland), spanning the period 2000-2019. Statistical data obtained from World development indicators statistical database (World Bank, 2025).

Table 2 offers some descriptive statistics and figure 1 the correlation matrix.

Table 2- Descriptive Statistics

	CO2	REN	GDP	EC	UNM
count	126	126	126	126	126
mean	268,33	28,03	1,11E+12	78,03	10,50
std	264,62	16,99	1,14E+12	21,15	5,64
min	7,43	3,53	8,19E+09	50,95	2,12
25%	66,03	14,33	2,33E+11	64,06	7,09
50%	176,26	25,15	7,86E+11	72,95	9,04
75%	368,35	38,41	1,84E+12	81,64	11,59
max	885,82	72,52	4,05E+12	142,42	27,69

Figure1- Correlation Matrix

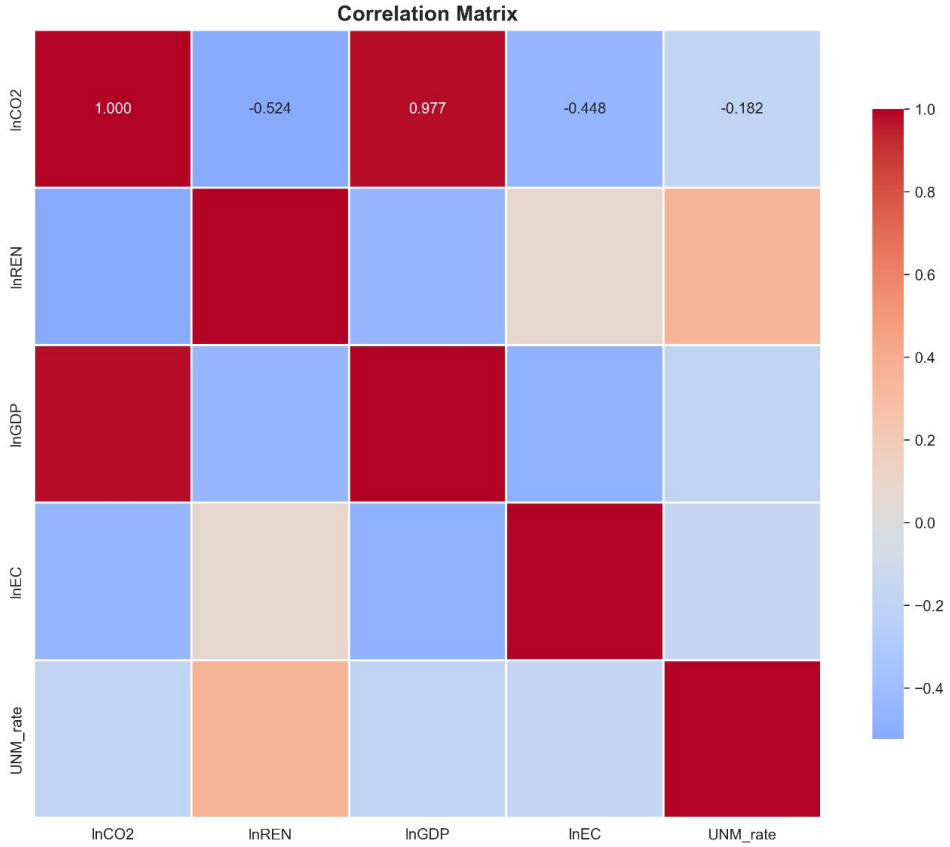
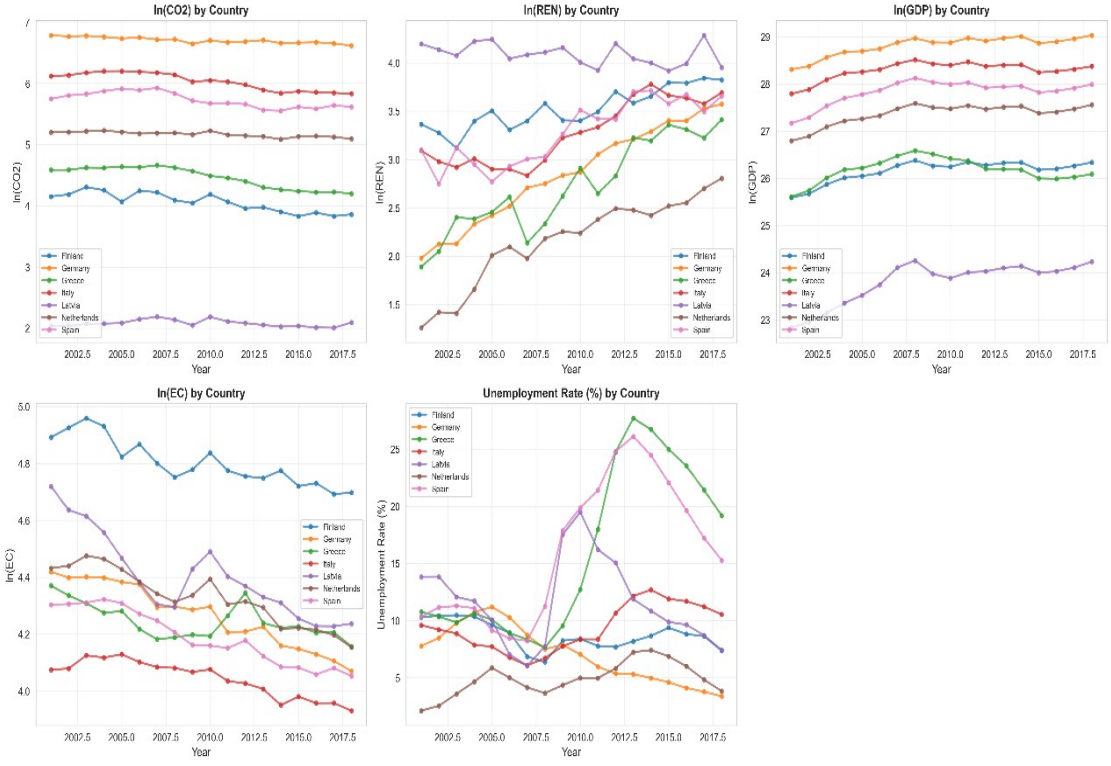


Figure2- Time Series plots



The data reveals a complex interplay between economic performance and environmental impact, characterized by distinct regional and structural differences. From Figure 2, which represents the time series of variables, we can see that the sample of countries selected is quite representative of the diversity that prevails in the European Union. There are industrialized countries with consistently high carbon dioxide emissions such as Germany, but also countries with a small footprint such as Latvia. In most countries, carbon dioxide emissions are clearly declining, because of the concerted efforts of the European Union institutions. In the use of energy from renewable energy sources, Latvia and Finland maintain the highest historical levels, while Germany demonstrates a steady upward trend, reflecting aggressive transition policies. Economic growth remains steadily upward over the period under review, as does energy consumption. Unemployment, on the other hand, is relatively uneven, and the data includes countries that suffered great damage from the debt crisis of the previous decade.

4. EMPIRICAL RESULTS

To investigate the validity of the environmental Phillips curve for sample countries using panel data, we employ the cross-sectional Panel Autoregressive Distributed Lag (CS ARDL) model proposed by Chudik and Pesaran (2015). The advantage of this model is that short-run and long run elasticities of the variables utilized are directly provided by the CS-ARDL model (Ullah et al., 2023).

The panel ARDL approach offers several methodological advantages: it accommodates both short-run dynamics and long-run equilibrium relationships, allows for heterogeneous cross-sectional units, and remains robust regardless of whether the underlying variables are integrated of order zero I(0), order one I(1), or mutually cointegrated.

The first step is to test cross-sectional dependence as based on CD Test proposed by Pesaran (2021). Table 3 shows the cross-sectional dependence analysis and the results reveal that a variation does exist in the coefficient of the variables. The validation of CD as suggested by the results means that any change in one country either in economic growth, renewable energy, energy consumption, or unemployment rate on carbon dioxide emissions has a ripple effect on each other.

Table 3- Results of cross-sectional dependence analysis

Variables	Test Statistic	P-Values
LnCO2	11.521*	0,0000
LnRNE	7.363*	0,0000
LnGDP	15.864*	0,0000
LnEC	14.515*	0,0000
LnUNEM	5.028*	0,0000

In the presence of cross-sectional dependence, we conducted CADF second-generation unit root testing at the level and first difference. Table 4 displays the findings from the CADF tests. At levels the result is mixed, but the first difference is for all variables stationary at significance level 5% and as a result all variables at first difference had integrated of order one, I(1).

Table 4 -Results of CADF unit root tests

Variables	**Level**	**Level P-value**	**First Difference**	**First Difference P-value**
lnCO2	-3.129	0.000	-5.130	0.000
lnGDP	-0.789	0.998	-2.191	0.050
lnGDPSQ	-0.778	0.998	-2.185	0.050
lnREN	-2.449	0.000	-4.758	0.000
lnEC	-3.294	0.000	-5.252	0.000
lnUNM	-0.945	0.998	-2.029	0.050

Table 5 presents the results of the Westerlund panel cointegration test (Westerlund, 2007). The outcomes of the cointegration test are demonstrated by both the statistical and panel groups (Gt, Ga) and (Pt, Pa). The findings indicate that the dependent and independent variables examined are significantly cointegrated over the long term. Consequently, the null hypothesis is rejected in favor of the alternative hypothesis. Once cointegration between the dependent variable and independent factors was established, the study advanced to panel data analysis. Accordingly, the CS-ARDL test was applied following stationarity and cointegration assessments to analyze short-term and long-term relationships among economic growth, renewable energy, energy consumption, unemployment rate and CO_2 emissions.

Table 5- Westerlund cointegration test results

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-3.52***	3.9	0.09	0.00
Ga	-0.15	3.41	1.00	0.81
Pt	-4.61***	-0.31	0.06	0.00
Pa	-0.90	2.32	0.99	0.59

Table 6 presents the results obtained from the CS-ARDL model. A significant negative ECT term indicates that the speed of adjustment is -0.84, meaning the ECT will return to long-run equilibrium at this rate. The empirical findings indicate that unemployment rate and energy consumption are the primary significant drivers in both the short and long run. Specifically, unemployment rate holds a negative relationship with the dependent variable, significant at the 10% level in the short-run and the 5% level in the long-run, suggesting that as unemployment rises, carbon dioxide emissions tend to decrease. Energy consumption exhibits a strong positive and statistically significant impact. Renewable energy and GDP show negative and positive coefficients respectively, but fail to reach statistical significance. The negative and statistically significant coefficients for unemployment rate in both the short-run and the long-run lend support to the existence of an Environmental Phillips Curve within the context of this study.

Table 6- CS-ARDL results

Variable	Short Run			Long Run		
	Coefficient	P-Values		Coefficient	P-Values	
REN	-0,1190	0,1931		-0,1745	0,3248	
GDP	0,1274	0,1987		0,0592	0,4336	
UNM	-0,0140	0,0646	*	-0,0072	0,0239	**
EC	0,7301	0,0012	***	0,6001	0,0395	**
ECM	-0,8469	0,0004	***			

5. CONCLUSIONS

The purpose of this paper is to investigate the effect of employment on environmental degradation, in the context of the Environmental Philips Curve framework for the countries members of the European Union. For this reason, we used a sample of seven European countries for the period 2000-2019. The panel data estimation models was based on CS-ARDL and Westerlund's cointegration test. The empirical validation of the Environmental Phillips Curve in this study presents a significant policy challenge for the European Union. The finding that higher unemployment is associated with lower carbon emissions in both the short and long- run confirms that, historically, emissions reductions have often been a byproduct of economic slowdowns rather than structural reform. This suggests a fundamental conflict where prioritizing jobs can inadvertently hurt the environment. While the transition to a low-carbon economy aims to foster green jobs, it simultaneously triggers a process of creative destruction that eliminates roles in carbon-intensive sectors.The fact that renewable energy was found non-significance in the results suggests that current green initiatives have not yet reached the scale necessary to decouple employment growth from emissions. In order to break the EPC trade-off, innovation must ensure that new production methods are both employment-friendly and less polluting. Governments should implement national reskilling programs specifically designed for workers in the energy, waste, and industry sectors. These programs must focus on the technical skills required for renewable energy maintenance and green manufacturing to reduce the "time and effort" lag currently hindering labor adaptation.

References

Adamopoulos, A. (2021). "Energy and economic growth an empirical analysis", Theoretical and Applied Economics, 28, 1(626), 151-166.

Anser, M. K., Apergis, N., Syed, Q. R., & Alola, A. A. (2021). Exploring a new perspective of sustainable development drive through environmental Phillips curve in the case of the BRICST countries. Environmental Science and Pollution Research, 28(35), 48112–48122. https://doi.org/10.1007/s11356-021-14056-5

Azimi, M. N., & Rahman, M. M. (2024). Examining the environmental Phillips curve hypothesis in G7 nations: Critical insights from wavelet coherence and wavelet causality analysis. Quality & Quantity, 58(6), 5683–5713. https://doi.org/10.1007/s11135-024-01909-7

Bhowmik, R., Syed, Q. R., Apergis, N., Alola, A. A., & Gai, Z. (2022). Applying a dynamic ARDL approach to the Environmental Phillips Curve (EPC) hypothesis amid monetary, fiscal, and trade policy uncertainty in the USA. Environmental Science and Pollution Research, 29(10), 14914–14928. https://doi.org/10.1007/s11356-021-16716-y

Chudik, A., & Pesaran, M. H. (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. Journal of Econometrics, 188(2), 393–420. https://doi.org/10.1016/j.jeconom.2015.03.007

Daştan, M., & Eygü, H. (2023). An empirical investigation of the link between economic growth, unemployment, and ecological footprint in Turkey: Bridging the EKC and EPC hypotheses. Environment, Development and Sustainability, 26(7), 18957–18988. https://doi.org/10.1007/s10668-023-04106-y

Djedaiet, A. (2023). Does environmental quality react asymmetrically to unemployment and inflation rates? African OPEC countries' perspective. Environmental Science and Pollution Research, 30(46), 102418–102427. https://doi.org/10.1007/s11356-023-29621-3

Karsiotis, P. & Adamopoulos, A. (2025). "The impact of economic growth and energy consumption on environmental quality", Sustainable Development, Culture, Traditions Journal, vol. 7a, σελ.54-64

Kashem, M. A., & Rahman, M. M. (2020). Answer to the letter to the editor on "Environmental Phillips Curve: OECD and Asian NICs Perspective". Environmental Science and Pollution Research, 27(34), 43412–43413. https://doi.org/10.1007/s11356-020-11001-w

Koyuncu Çakmak, T., Beşer, M. K., & Alola, A. A. (2025). Environmental effect of high-, upper, and lower middle-income economies' energy mix: Is there a trade-off between unemployment and environmental quality? Energy & Environment, 36(2), 851–869. https://doi.org/10.1177/0958305X231187034

Ng, C.-F., Yii, K.-J., Lau, L.-S., & Go, Y.-H. (2022). Unemployment rate, clean energy, and ecological footprint in OECD countries. Environmental Science and Pollution Research, 30(15), 42863–42872. https://doi.org/10.1007/s11356-021-17966-6

Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. Empirical Economics, 60(1), 13–50. https://doi.org/10.1007/s00181-020-01875-7

Shastri, S., Mohapatra, G., & Giri, A. K. (2022). The Environmental Philips Curve from a gender perspective: Empirical evidence from India. Environmental Science and Pollution Research, 30(7), 17487–17496. https://doi.org/10.1007/s11356-022-23336-7

Tariq, S., Mehmood, U., Ul Haq, Z., & Mariam, A. (2022). Exploring the existence of environmental Phillips curve in South Asian countries. Environmental Science and Pollution Research, 29(23), 35396–35407. https://doi.org/10.1007/s11356-021-18099-6

Teeli, A. A., Rao, Ch. S., Lone, A. R., Soltani, H., & Ben-Salha, O. (2025). Zero Emissions and Zero Unemployment: A Feasible Future or Conflicting Objectives? International Journal of Energy Economics and Policy, 15(3), 727–734. https://doi.org/10.32479/ijeep.19087

Ullah, A., Raza, K., & Mehmood, U. (2023). The impact of economic growth, tourism, natural resources, technological innovation on carbon dioxide emission: Evidence from BRICS countries. Environmental Science and Pollution Research, 30(32), 78825–78838. https://doi.org/10.1007/s11356-023-27903-4

Westerlund, J. (2007). Testing for Error Correction in Panel Data*. Oxford Bulletin of Economics and Statistics, 69(6), 709–748. https://doi.org/10.1111/j.1468-0084.2007.00477.x

World Bank (2024) World development indicators, databank.https://worldbank.org/source/world-development-indicators

Yavuz, E., Kilic, E., & Caglar, A. E. (2023). A new hypothesis for the unemployment-environment dilemma: Is the environmental Phillips curve valid in the framework of load capacity factor in Turkiye? Environment, Development and Sustainability, 26(11), 29475–29492. https://doi.org/10.1007/s10668-023-04258-x