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# Environment degradation, economic growth and energy consumption nexus: A wavelet-windowed cross correlation approach

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## HIGHLIGHTS

- The aim is to analyse the causal relationship between CO2 emissions, EG and EC.
- We use a new technique namely wavelet windowed cross correlation.
- The results show significant uni/bidirectional causalities depending on the country.
- The results validate both the EKC as well as the feed-back hypothesis.

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## ABSTRACT

This paper analyzes the interactive linkages between carbon dioxide ($CO_2$) emissions, energy consumption (EC) and economic growth (EG) using a novel approach namely wavelet windowed cross correlation (WWCC) for six oil-exporting countries from the GCC (Gulf Cooperation Council) region over the period 1980–2012. Our empirical results show that there exists a bidirectional causal relationship between EC and EG. However, the results support the occurrence of unidirectional causality from EC to $CO_2$ emissions without any feedback effects, and there exists a bidirectional causal relationship between EG and $CO_2$ emissions for the region as a whole. The study suggests that environmental and energy policies should recognize the differences in the nexus between EC and EG in order to maintain sustainable EG in the GCC region. Our findings will be useful for GCC countries to better evaluate its situation in the future climate negotiations. The overall findings will help GCC countries assess its position better in future climate change negotiations.



## 1. Introduction

The interactive relationship between carbon dioxide (hereafter, $CO_2$) emissions, Energy Consumption (hereafter, EC) and economic growth (hereafter, EG) has been extensively tackled in the environmental economic literature. Innumerable empirical methodologies and datasets that insert different characteristics are used. However, studies find no convincing

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findings regarding the interplay between the three variables.[2] Ozturk [2] points out that no substantial findings were provided by the majority of previous works devoted to study the causality relationship between environmental degradation, energy uses and EG. Similarly, Dinda [1] concludes that previous works are not able to provide concrete evidence when the negative correlation between $CO_2$ emissions and EG arise. Payne [3] argues that the main lack of guidance encountered in the interpretation of the empirical results were mainly due to the use of different methodologies and datasets containing multiple characteristics. These anomalies may highlight deficiencies in economic policy implications and recommendations generated by conflicting and unreliable findings. Dinda [1] and Ozturk [2] address this issue by requiring new economic modelling in order to provide key and useful information about the linkages between EC, EG and $CO_2$ emissions. They attest that more attention should be paid to new approaches and refreshing perspectives rather than being limited to standard methods applied to a set of common variables for various countries, a given region and different sample periods.

There are three empirical research strands devoted to the causality linkage between EC, $CO_2$ emissions and EG in the environmental economic literature. The first strand is concentrated on the validity of the so-called "Environmental Kuznets Curve" (EKC) hypothesis for a single country or a balanced panel. The EKC is a hypothesized relationship between environmental impact indicator ($CO_2$ emissions among others) and EG where the association between those variables reveals that EG is initially linked with high $CO_2$ emissions which then tends to decrease as the economy reaching turning point or threshold level of EG. In other words, the relationship between environmental degradation indicators and EG follows an inverted U-shaped curve. Since the publication of Grossman and Krueger [4]'s empirical studies on the cross-linkage between EG, EC as well as many environmental pollutants were mainly dealing with EKC hypothesis which become subject to an intensive research over the last few decades. The second strand of researches is concerned with the nexus between EC and EG. Briefly, this nexus suggests that higher EG is resulting in more EC and more efficient energy use needs higher level of EG.[3] Finally, the third strand of research makes the connection between EG, EC and $CO_2$ emissions. The main underlying idea is to explore the nexus between EG and EC and $CO_2$ emissions by considering them simultaneously. Empirical studies devoted to such interactive linkage are extremely abundant in the environmental economic literature. Broadly speaking, they revealed that EG would likely lead to changes in $CO_2$ emissions and showed that EC is key determinant of $CO_2$ emissions.

In Table A.1 (see Appendix), we summarize the results reached by previous studies (relatively to the three aforementioned strands) on the connection between EG, EC and $CO_2$ emissions including the period of study, sample countries, econometric tool and the key finding. Given the heterogeneity of the results, it is difficult to reach a conclusion on the interactive relationship between EC, $CO_2$ emissions and EG. Furthermore, from this review it can be concluded that for the most countries involved, almost all types of causality (unidirectional causality, bidirectional causality and no causality) has been reported in the literature. These diverse findings arise out of the use of different datasets, various econometric methodologies and different countries' features. The main contribution of this paper is to provide useful findings to better understanding of the cross-linkage between EC, EG and $CO_2$ emissions in the Gulf Cooperation Council (GCC) countries using a novel approach based on the Wavelet Windowed Cross Correlation (WWCC) function. The main motivations behind the use of the latter method arise in the desire to extract intrinsic characteristics inherent to the time series as well as to obtain specific theoretical foundations.

In this perspective, it is well recognized that the analysis of co-movement between time series is an important issue that has been long posed challenge to various economic agents and academic researchers. The first and foremost reason is that the historical data of financial time series are the outcome of a complex economic process that include, among others, continuing structural changes, policy shifts, real and financial shocks, crises, political tensions, and wars [19]. The combined effects of these events are the root of stylized (and well-known) distributional characteristics of financial time series such as asymmetry, nonlinearity, heavy-tailness, and extreme values. Au et al. [20] note that disregarding these irregularities during the statistical modelling tasks may lead to misleading conclusions. Besides, Haven et al. [21], and Sun and Meinl [22] stress that most data generating processes convey noises that are caused by the complex structure of irregularities and roughness. They thus suggest the use of wavelet analysis to denoise the data and to address the manifold irregularities along with both time and different measuring scales. As pointed by Jammazi [23], in recent years practitioners have emphasized on the decomposition methods in order to capture drifts or spikes relatively to major economic aggregates and particular interests have been given to wavelet analysis due to their ability to decompose any signal into their time scale components, their flexibility to handle non-stationary data and their capacity to provide an alternative representation of the variability and association structure between variables on a scale-by-scale basis.

Regarding the theoretical foundations, the wavelet appeared to be an important tool contributing to a better assessment of the causal relationship between EC, EG and CO2 emissions. Tellez et al. [24] consider wavelet to test the validity of the EKC hypothesis for the NAFTA countries (USA, CANADA and Mexico). According to them, the apparent advantage of wavelet tool is that it allows seeing "the whole forest while analysing specific trees". It is worth noting that the expected $CO_2$ emission levels present in the atmosphere can change drastically over time and hence their subsequent effects on the environment

2 Dinda [1], Ozturk [2] and Payne [3] surveyed previous works.

3 The most relevant contributions of this strand can be found since the pioneering work of Kraft and Kraft [5]. Then a lot of recent works using several approaches appeared including; Dagher and Yacoubian [6]; Salahuddin and Gow [7], Herrerias et al. [8]; Alshehry and Belloumi [9]; Pao and Tsai [10], Ansgar and Dobnik [11]; Farhani and Ben Rejeb [12], Saboori and Sulaiman [13], Saboori et al. [14]; Arouri et al. [15]; Ozcan [16]; Mohammadi and Parvaresh [17] and Omri et al. [18].