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# A semi-parametric panel data analysis on the urbanisation-carbon emissions nexus for the MENA countries

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ABSTRACT

This study seeks to examine the impacts of urbanisation on carbon emissions through the investigation of the existence of an environmental Kuznets curve (EKC). Within the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) framework, this is the first study in the MENA region to explore the urbanisation and carbon emissions nexus; using panel data together with a semi-parametric panel fixed effects regression. The data set refers to a panel of 20 countries in the MENA region spanning the period 1980–2014. According to the results; there is little evidence to support an inverted-U shaped relationship between urbanisation and carbon emissions in the region. More specifically, it was found in the region and with the continuation of the urbanisation process, carbon emissions per capita decreased. In addition, the results suggest that energy use and economic growth are the main sources of carbon emissions in the region. The results imply that policies to reduce carbon emissions in the countries with relatively higher carbon emissions, should concentrate more on energy use and the pattern of economic growth and not the urbanisation issue.

## 1. Introduction

It is widely accepted that the MENA region is significantly impacted by climate change [1,2]. Empirical studies that have addressed this issue, in the region, have agreed that energy use and/or consumption and economic growth are the key sources of $CO_2$ emissions [2–5]. The extensive use of energy in the region is attributed to high subsidies on petroleum products. This has encouraged an exaggerated and inefficient use of fossil energy. Studies have shown that eleven out of twenty countries in the world which subsidise gasoline consumption are from the MENA region [6]. According to International Energy Agency [7], the region is ranked at second place after North America in carbon emission and documented 9 metric tons of $CO_2$ per person, which is higher than the average value in Africa (1.1), Asia (3.7), Europe (7.1), and is higher than the worldwide average of (4.6) [2].

However, recently in addition to energy use and/or income level, urbanisation has been identified as one of the significant factors that can explain the quality of the environment [8–10]. Some of the possible effects of urbanisation on environmental quality are independently debated in three relevant theories. The first is the ecological modernisation theory, which claimed that environmental problems may rise from low to intermediate stages of development. Nonetheless, additional modernisation can reduce such inverse impacts; as societies start to recognise the significance of environmental sustainability. The second is the urban environmental transition theory; where an increase in affluence of cities often leads to an increase in manufacturing activities; leading to massive industrial pollution-related issues such as polluted air and water. However, such adverse impacts decrease in affluent cities as the result of advanced environmental regulations, technological progress and structural improvements in the economy. The third is the compact city theory; where high urban density allows cities to accomplish economies of scale of urban public infrastructure and decreases car usage, travel length, allocation losses of electricity supply, and minimising energy consumption and thus $CO_2$ emissions [11–14].

Although MENA countries on average have lower urban populations compared to some other regions such as the OECD countries and North America, they have registered a relatively higher urban population growth rate. For instance, in 2014, the urban population in the MENA countries accounts for 64% of the population, this is lower than that of OECD (80%) and North America (81%). However, we see a different story when we consider the growth rate of the urban population. Fig. 1 represents the urban population growth (annual %) in the MENA countries and some selected regions during the period 1980–2014. From the figure, it is clear that while the urban population growth rate in the selected regions and worldwide decline over time, the MENA region remains the one with the highest annual growth rate in the urban population [1].

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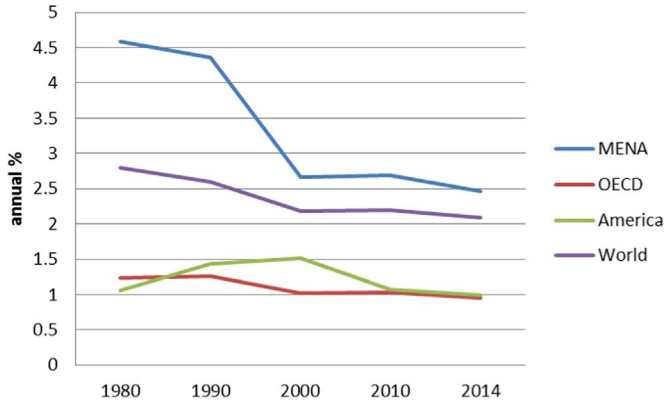


**Fig. 1.** Urban population growth rate (annual %) in MENA and selected region, 1980–2014 [Authors' calculations].

There have been contradicting debates on the urbanisation - environment nexus, as well as the current statutes of the MENA region in the context of urbanisation and the environment, which raises the following question; Does the urbanisation phenomena increase or decrease environmental deterioration in MENA countries? The answer to this question, which is the main concern of this study, has great policy implications. If the relationship between urbanisation and environmental degradation is found to be a monotonously (linear) positive relationship, then environmental quality will continue to deteriorate with the increase of urbanisation. Only when urbanisation enters a stage of stagnation, the tendency towards environmental degradation would slow down. Therefore, policymakers should adopt policies that minimise the urbanisation process to avoid environmental deterioration. However, if the results show a monotonously negative relationship between urbanisation and environmental degradation, then environmental quality will continue to improve even with the continuation of the urbanisation phenomenon. Hence, policymakers should facilitate rural-urban migration to maintain the quality of the environment. In contrast, if a non-monotonous (nonlinear) curved link is found between urbanisation and environmental quality, environmental degradation may be reversible and environmental quality may be recoverable. To the best of the authors' knowledge, this is the first empirical study in the MENA region, to investigate the EKC hypothesis on $CO_2$ emissions related to urbanisation within the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model. Most importantly, instead of using the parametric fixed panel; a method that has been used extensively in previous studies, in this study we employ the semi-parametric regression developed by Baltagi and Li [15]. According to Wang et al. [9], the semi-parametric regression is a consistent estimation method for a dynamic partially linear panel data model with fixed effects. In contrast to the parametric panel fixed effects regression, the semi-parametric panel fixed effects regression is more flexible, which enables the addressing of potential functional form misspecification [16]. Also, it partially avoids dimensionality problems by combining features of both the parametric and nonparametric techniques. A further advantage of the semi-parametric panel fixed effects regression is the possible inclusion of a concise economic interpretation of the results.

The remaining sections are organised as follows. Section 2 briefly describes the empirical evidence from the existing literature. Sections 3 and 4 examine the models, estimation methods and the data sources used to test the EKC hypothesis. The empirical results and the related discussion are presented in Section 5. The final section; Section 6 contains the concluding comments and policy implications.

## 2. Literature review

While several studies have addressed the determinates of $CO_2$ emissions in the MENA region, only a few have considered urbanisation as one of these determinants. In addition, no studies have addressed the issue within the STIRPAT framework and employed a semi-parametric panel fixed effects technique. While most of these studies have usually adopted either IPAT or an *ad-hoc* model as their framework, the estimation techniques that were employed range between cointegration and fixed effect models. In reviewing the previous studies related to $CO_2$ emissions in the MENA region, we will, first, discuss studies that have addressed the determinates of $CO_2$ emissions in general and second, we will discuss the studies related to the urbanisation - carbon emissions nexus. Thereafter, we review some studies, outside of the MENA region, that have addressed the same issue within the STIRPAT framework and employed a semi-parametric panel fixed effects technique, which is compatible with the methodology used in this study.

We classified the first group of studies into country-based studies and panel or cross countries-based studies. Based on the country-level analysis, Fodha and Zaghdoud [17] investigated the validity of the EKC hypothesis for Tunisia using two indicators for pollutant emissions ($SO_2$ and $CO_2$), during the period 1961–2004. Employing the Johansen approach for cointegration, as well as the Granger causality test, the study arrived at the evidence in support of the EKC hypothesis when $CO_2$ had been used as a proxy for pollutant emissions. In contrast, a monotonically increasing relationship with GDP was found to be more appropriate for $CO_2$ emissions. The causality test detected a unidirectional causality relationship running from income to environmental changes; both in the short-run and long-run. Alkhathlan and Javid [18] examined the relationship among economic growth, carbon emissions, and energy consumption at the aggregate and disaggregate levels for Saudi Arabia during the period 1980–2011. For the aggregate model, the authors used the total energy consumption per capita and $CO_2$ emissions per capita based on the total energy consumption. For the disaggregated analysis, they used oil, gas and electricity consumption along with their respective $CO_2$ emissions. The results of the Autoregressive Distributed Lag (ARDL) technique showed that the estimated long-term income elasticities of carbon emissions are higher than the estimated short-term income elasticities of carbon emissions; which implied that over time, per capita carbon emissions increase with the rise in per capita income in Saudi Arabia. This result indicated that there is a monotonically increasing relationship between carbon emissions and per capita income in Saudi Arabia. Likewise, Al-Rawashdeh et al. [19] examined whether or not the EKC relationship exists between economic growth and two environmental pollution indicators ($SO_2$ and $CO_2$) based on a country level analysis using time series data for 22 MENA countries. At the country level, the results suggested evidence of an $SO_2$ – EKC for Algeria, Tunisia, Yemen, Morocco, Turkey, and Libya. Regarding $CO_2$, the findings also supported an inverted U-shaped pattern associated with the EKC hypothesis for Tunisia, Morocco, Turkey and Jordan. When analysing the MENA region as a panel, the results showed that there is no EKC evidence for $SO_2$ and $CO_2$ emissions, but there is only a monotonically increasing linear relationship between income and $CO_2$ emissions.

M'henni [20] tested the EKC hypothesis in Tunisia over the period 1980–1997. The author employed the Generalized Method of Moments (GMM) technique and examined the following pollutants: $CO_2$ emissions, fertilisers' concentration and the number of cars in traffic which serve to calculate an index for environmental quality. The results showed that there was no evidence to confirm the EKC for any of these pollutants. Based on the cointegration analysis, again, Chebbi et al. [21] examined the same issue for Tunisia and arrived at different results. More specifically, they detected a positive linkage between trade openness and per capita emissions and a negative linkage between economic growth and per capita pollution emissions in the long-run. Akbostanc et al. [22] examined the relationship between $CO_2$, $SO_2$ and PM10 (particulate matter 10 micrometres or less in diameter) emissions. They examined the EKC in Turkey at both the national level,