Analyzing the impacts of technological innovation on CO2 emission "Innovation Claudia Curve Theory (ICC)" in MENA Countries

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Overview:

In recent years, due to the serious effects on the environment, there have been intense discussions about concepts that refer to the destruction of the environment, such as global warming and climate change. Accordingly, the Environmental Kuznets Curve (EKC) hypothesis, which was proposed by Kuznets (1955) to deal with the effects of economic growth on environmental destruction, has become a popular research topic. Furthermore, the concept of technological innovation is attributed to Schumpeter (1942) and most researchers believe that change in technological innovations has a vital importance in explaining and addressing key issues in the environment.

This study not only examines economic growth in terms of environmental impact, but also adopts a modified EKC theory to investigate the impact of technological innovation and consumption of renewable and non-renewable energy on significantly increasing CO2 emissions in selected MENA countries. Thus, this paper will be particularly useful for decision makers to help them adopting policies that contribute to promoting technological innovations to reduce these emissions and their negative effects on the environment, especially since most of these countries use non-natural resources in their economic growth.

Several empirical studies have been conducted in various countries to investigate the variables that affect the environment. In this context, Vo and Vo (2021) emphasized that sustainable economic growth in the ASEAN region is accomplished by moderating population growth with higher use of renewable energy, in addition, renewable energy usage responds to population growth and leads to CO2 emissions. Moreover, many studies have found a causality between economic growth, energy consumption and CO2 emissions (Tzeremes, 2018; Vo and Vo ,2021).

In term of MENA country there have been many studies investigate the importance of reducing the CO2 emissions by studying various variables such as Alharthi et al. (2021) concluded that economic growth destroys the environment while renewable energy reduces carbon emissions. Moreover, S. P. Nathaniel et al. (2021) tested the Environmental Kuznets Curve (EKC) theory in the MENA region and pointed out that there is existence of a bidirectional causal connection in both the short and long term between energy consumption and economic growth. In terms of policy effectiveness Kahia et al. (2017) found that renewable energy policies have a significant and positive effect on encouraging and helping the economy grow.

Recently, technological innovation has been incorporated as a new indicator into the growth-environment framework, as it is recognized as an important component in the reduction of CO2 globally. Extant research has been done on how innovations affect carbon emissions .For example ,Khan et al . (2020) revealed that technological innovation diminishes CO2 emissions in China .Meanwhile, Mensah et al. (2018) showed that technological innovation plays a key role in mitigation of CO2 emissions and enhances environmental quality.

Methods:

This study will adopt the modified innovation EKC model (Innovation Claudia Curve theory) to analyze the effect of innovation technology on CO2 emissions and examine the existence of an inverted U-shaped curve between innovation and environmental quality in selected MENA countries., the model is shown as follows:

$$CO2_{it} = \alpha_0 + \beta_1 GDP_{it} + \beta_2 GDP^2 + \beta_3 PAT_{it} + \beta_4 PAT^2{}_{it} + \beta_5 NPAT_{it} + \beta_6 NPAT^2{}_{it} + \beta_7 REC_{it} + \varepsilon_{it}$$

The paper will focus on only 6 MENA countries due to availability of data these countries are: Algeria, Egypt, Iran, Morocco, Saudi Arabia, Tunisia. from 1990 to 2019.

The main variables for the study are CO2 emission per capita (as dependent variable) and innovation as independent variable (PAT as a measure of patent application by resident and NPAT as non-resident). This proxy for innovation has been employed by (Chuzhi & Xianjin,2008; Khan et al.,2021) and came

to the same conclusions proving that patents have a beneficial effect on CO2 emissions. Also, our study further added the following explanatory variables: GDP is gross domestic product per capita (constant 2015 US$), REC is renewable energy consumption (renewable energy consumption % of total final energy consumption), while ε is the error term. In addition, in empirical analysis. Thus, this paper uses the panel FEM, EGLS estimation methods.

Empirical result:

This paper aims to assess the modified innovation EKC model (Innovation Claudia Curve theory) and analyze the effect of using renewable energy, economic growth, and innovation technology on CO2 emissions. In addition, it attempts to examine the existence of a U-shaped curve between innovation and environmental quality in a selected MENA country for 1990–2019 by applying the panel Fixed effect (FE) and generalized least squares (EGLS) estimation methods. The empirical econometric results reveal that the Innovation Claudia Curve (ICC) is valid for the selected countries, and the quadratic patent variable shows that initially the use of innovation technology increases emissions, but after a certain level, a turning point occurs, and patents have a significant impact on environmental quality. Thus, the results support the idea that as more patents are developed and used, the quality of the environment improves and the levels of environmental degradation decrease.

In a panel study, we looked at how innovation affects carbon emissions. After confirming the cross-section dependents between countries, we begin to verify the stationarity of the data by using second-generation panel unit root tests to determine the stationarity of the variables. According to the results of the CIPS panel unit root tests, CO2, GDP, PAT, $PAT^2$and NPAT,N PAT^2 are non-stationary at levels but become stationary at first differences, whereas the REC is stationary at levels. Then, testing for cointegration gives us another way to look at how variables are connected. The cointegration test by Westerlund (2007) is used to deal with the problem of heterogeneity and cross-sectional dependencies. The outcomes show the results of no cointegration between variables.

In the empirical approach, we estimate the model by using two methods: fixed affect (FE) and generalized least squares (EGLS). The results from the fixed-effect model show that GDP, PAT, and PAT^2 are statistically significant, which illustrates that the impact of GDP on carbon emissions is negative and significant. And the square of GDP has a significant positive impact on CO2 emissions, which conforms to the existence of Kuznets's curve in MEANA countries. This finding is consistent with other studies that hypothesize the existence of the Kuznets curve, such as (Nathaniel, Adeleye, and Adedoyin 2021). On the other hand, the renewable energy consumption is positive but not significant, whereas with the resident patent it is positive and significant, expressing the impact of the patent on the carbon emission. The patent square demonstrates a significant negative relationship with carbon emissions, confirming the Claudia theory's inverse U-shape. Where, according to the Claudia Curve theory, increasing carbon will be mitigated by technologies (innovations), the first will initially increase emissions due to limited accessibility, but further increases will gradually lower emissions. When more technologies are protected by patents, high technology spillovers will reduce CO2 emissions. Finally, the nonresident patent has no impact on reducing carbon emissions. In comparison to EGLS methods, where all variables are statistically significant, the Kuznets model does not exist here, where GDP and GDP square have a positive sign, which means that increasing GDP by one unit leads to an increase in CO2 emissions by 0.0005, which is a very small impact. The consumption of renewable energy is negative, with a 0.02 reduction in CO2 when consuming a unit of renewable energy. The paper's focus is on innovation and its impact on improving environment quality where the resident patent has the inverse Claudia U curve, while the nonresident patent has a U shape.

Conclusion:

The results from our analysis are confirmed the validity of Claudia curve theory (ICC). The findings reveal the impact of technological innovation on mitigating the level of CO2 emission in selected MENA countries, indicating the positive relationship between patent and CO2 emission on one side. Furthermore, the quadratic patent variable illustrates a negative relationship with CO2 emission. In other words, the use of technologies initially causes environmental degradation, but beyond a certain degree of discovery of more patents the quality of the environment improves and the levels of environmental degradation decrease.