Journal of Environmental Science and Economics ISSN:2832-6032
https://doi.org/10.56556/jescae.v1i2.17

RESEARCH ARTICLE

Dynamic relationship between Air pollution and Economic growth in Jordan: An Empirical Analysis

Seun Adebowale Adebanjo[1*],Twahil Hemed Shakiru[2]

[1]Statistical training and Consultation Nigeria
[2]Jiangxi University of finance and Economics, China

Corresponding Author: Seun Adebowale Adebanjo, seunadebanjo9@gmail.com
Received: 04 February, 2022, Accepted: 30 March, 2022, Published: 01 April, 2022

Abstract
Apparently, throughout human history, pollution and the economy appear to have been inextricably linked. However, the relationship between environmental harm and economic development is complex, and disciplinary biases have splintered our understanding of it. This study applies Johansen cointegration which indicate that there exists a long-term relationship between air pollutants and economic growth. Multiple regression model indicates that there is a significant relationship between air pollution variables and the economic growth. The vector autoregressive model (Var) indicates a short run relationship between the variables. Then, Vector error correction model was fitted and the Environmental Kuznets Curve (EKC) is supported. More so, the EKC shows that economic growth has both positive and negative significant impact on air pollution. Meanwhile, Granger causality test shows that economic growth has causal effect on air pollution. This indicates that Jordan has reduced CO2 emissions along with other pollutants and thereby contributed to environmental improvement in the country.

Keywords: Air pollution, Environmental Kuznets curve (EKC), Cointegration test, Var model, VECM, Causality test, Multiple regression

Introduction

There has been a lot of discussion in natural and social sciences about how pollution and economic development interact. The Environmental Kuznets curve has begun to blur some of the less obvious interrelationships between economic development and environmental outcomes (Ozokcu S, Ozdemir O, 2017). It is critical to consider the carrying capacity of the ecological system. Furthermore, many studies are conducted in narrow contexts, which prevents us from putting an integrated framework to the test. In order to advance towards a circularity, we must look at how to take advantage of pollution as a material asset in the products. Especially in the less developed countries, where pollution levels are increasing rapidly, government regulations often face the challenge of conflicting narratives on economic growth and human development. Meanwhile, without tighter controls, air pollution emissions and concentrations are expected to rise rapidly, posing a serious threat to human health and the environment. The negative health effects of air pollution are expected to result in significant economic costs, with significant annual global welfare costs at the regional and sectoral levels (Jalil and Feridun, 2011). Furthermore, air pollution can harm trees and crop yields in a variety of ways (Rupakheti, 2015). Reduced crop and forest yields, reduced tree growth and survivability, and increased susceptibility to plant diseases, pests, and other stresses are all possible consequences of ground-level ozone (for instance, harsh weather). Jordan's government has made significant progress in its ability to reduce environmental degradation over the last decade.

This progress has been made possible by a stronger legislative framework, stronger institutions, and a number of publicly funded projects. The Ministry of Environment has accomplished the following since its inception in 2003: Initiated efforts to improve the treatment of industrial wastewater (establishing an industrial wastewater treatment plant in Irbid recently in partnership with the private sector, with plans in the works for a second plant in Zarqa); medical and hazardous wastes (a plant set to open at the end of 2009 will treat roughly 70% of the annual waste flow); and other wastes (a plant set to open at the end of 2009 will treat roughly 70% of the annual waste flow); and other wastes (a plant set to open at the end of 2009 will Updated and comprehensive regulations, soon to be adopted, have improved the inspection system; Played a key role in the formation of the environmental rangers department in 2006, which has improved the effectiveness of vehicle inspection, among other things; and Public consultations on a variety of environmental issues were promoted in collaboration with local NGOs.

Jordan's air quality has significantly improved as a result of air quality initiatives (EEA, 2017). The three main air pollution investigated in this study are nitrogen dioxide, ozone, and carbon dioxide. Besides, CO2 emissions from gasoline use account for more than 60% of the greenhouse impact (Ozturk I, Acaravci A. 2020) and are the primary source of energy for the industry in general, and the automobile industry in particular, both of which are directly related to economic growth and development (Marjanovic V, Milovancevic M, Mladenovic I. 2016). While (Holtz-Eakin D, Selden TM. 2019) forecasted an annual growth rate of approximately 1.8 per cent in emissions until 2025, the most recent International Energy Outlook (EIA 2021) projected a 34 per cent increase in global energy-related CO2 emissions in 2040 relative to 2012, with developing non-OECD countries bearing a disproportionate share of the burden due to their continued reliance on fossil fuels to meet rising energy demand. However, oil, natural gas, and uranium resources are expected to run out within a few decades, and coal in nearly two centuries (Omer AM, 2019). As a result, the United Nations Environment Programme, through the International Resource Panel, recommended a strategic approach to achieving a low-carbon, resource-efficient Green Economy that seeks to decouple human wellbeing from resource consumption (UNEP 2018). Different from previous studies, this paper is prepared with the primary aim of investigating the dynamic relationship between Air pollution and Economic growth in Jordan using an empirical analysis approach and the following objectives are needed to achieve it:

- To study the relationship between economic growth on air pollution
- To examine a short run relationship between air pollutants and GDP Per capita
- To examine a long run relationship between air pollutants and GDP Per capita
- To fit a parsimonious VECM
- To study the causal effect between air pollution and GDP Per capita
- To examine the relationship between economic growth and air pollution.

Literature overview

Air pollution refers to a wide range of pollutants that are produced by a single or multiple agent. According to a European Commission study, approximately 82 percent of Europeans are exposed to air pollution (Gehrsitz 2017). Lower air quality is a major environmental problem that has an impact on humans due to air pollutants like nitrogen dioxide, carbon dioxide, and ozone (Collivignarelli et al. 2020). Air pollution is more concentrated in urban areas due to increased traffic and population density (Li et al. 2018; Qiu et al. 2019; Silva et al. 2018). The Cost of Environmental Degradation (COED,2006) in Jordan is calculated by considering both the immediate and long-term effects of degradation in a given year. The total COED is estimated to be in the range of JD 143–332 million, with an average of JD 237 million, or 2.35 percent of GDP in 2006, using a variety of well-established and internationally accepted methodologies. When the cost of emissions on the global environment is factored in, the total cost to Jordan and the rest of the world is JD 393 million. A substantial body of specialized work examines the relationship between national income levels and the need for improved environmental quality, referred to as the EKC hypothesis. According to (Kuznets S. 2018), income inequality increases initially with economic growth and then declines after the economy reaches a certain point. Using the same logic, the EKC hypothesis asserts that increasing economic growth will initially exacerbate environmental strain, but that at a certain point, increased economic growth will alleviate environmental pressure.

The other section of the literature investigates the causal relationship between energy use and economic growth. The pioneering work on the economic growth—energy consumption connection was conducted by (Kraft J, Kraft A. 2017), which established a unidirectional causal relationship between gross national product and energy consumption in the United States, whereas (Akarca AT, Long TV. 2019) established no causal relationship. Jordan has made significant progress in the energy and transportation sectors in adopting cleaner fuels. Natural gas's use in the power sector to replace diesel and heavy fuel oil has increased dramatically in recent years, reaching 77 percent of total fuel use in 2006. Furthermore, in 2008, Jordan began the phase-out of leaded gasoline and high-sulfur diesel in order to improve fuel quality and meet European EURO 4 emission standards. 6 In low-area, high-density hotspots of vehicular traffic and industrial activity, air quality is a problem. Vehicles, industries, and residential activities produce the most polluting emissions. Vehicles are a significant source of emissions in Jordan. The fleet of vehicles is rapidly growing, at a rate of 7 to 10% per year. 7 Despite this, the vehicle fleet is relatively old, with approximately 33% of the vehicles manufactured prior to 1990. When old cars are maintained and driven, they emit a significant amount of pollution. 8 Because Amman and South Amman are home to about 70% of all Jordanian automobiles (AFD 2006), they are a major source of pollution. Cement plants in Fuheis and Rashadeia, the industrial district of Hashimyeh in Zarqa, power plants, and phosphate and potash industries in Aqaba, among others, all contribute to industrial emissions. Mining is the largest significant source of air pollution, accounting for approximately 62 percent of total suspended particles (TSP), 78 percent of PM10, and 39 percent of nitrogen oxides (NO) produced by industry.

Recent environmental policy changes, such as the ban on diesel vehicles in urban areas, have been justified by federal court rulings in order to avoid further climate change (Giesberts 2018; Schmitz et al. 2018). In Jordan, air quality is one of the most pressing environmental issues of the day, and efforts to address it are ongoing (Zambrano et al. 2010). However, for air pollution parameters, this trend does not exist, indicating that pollution levels in Jordan did not decrease proportionally. This could be because emissions cause transformations when they are released into the atmosphere. Weather conditions, in particular, have a significant impact on pollutant distribution. For example, weather conditions with a high exchange between air layers cause particles to spread more widely, resulting in lower pollutant concentrations, and vice versa. These and other factors contribute to the fact that pollution levels vary by region. For example, nitrogen dioxide levels are higher in cities, whereas ozone-induced burdens are often more difficult in rural areas. Three different pollution parameters are used to assess air quality in this study. Carbon dioxide (CO2), nitrogen dioxide (NO2), and ozone are the three gases (O3). They are standard variables used to regulate air quality in Jordan (EEA, 2017). Combustion processes are the primary source of the gaseous pollutants CO2 and NO2 (e.g. heating or traffic). One of the most common types of smog is O3 at ground level. It is the result of sunlight reacting with other pollutants such as nitrogen oxides. However, this literature explores the association between national income levels measured by gross domestic product per capita (GDP Per capita) and the demand for greater environmental quality, namely the EKC hypothesis (Song, 2008). According to income inequity first rises with economic progress and then drops as economy advances to a certain level. Following the same reasoning, the EKC hypothesis points out that intensification in economic growth will primarily cause environmental pressure, but after a particular stage, increase in economic growth will lessen the environmental pressure. Specifically, EKC expects an inverted U-shaped association between environmental degradation and economic growth (Ozokcu, 2017). Meanwhile, economic growth will amplify CO_2 emanations, but after a certain level (turning point) this connection will come to be the opposite. For that reason, after a certain period, upsurge in economic growth will lessen CO_2 emissions (Halicioglu, 2009), accordingly, economic growth itself being the way out for an uncontaminated setting.

Research Methodology

The data collected for this paper work is secondary data extracted from world bank publications (https://www.data.worldbank.org), Institute for health metrics and evaluation (IHME) and countryeconomy.com from the period of 2000 to 2020. The Empirical approach adopted is vector error correction model (VECM), Johansen Cointegration test (Johansen, 1991), Granger Causality test, and EKC model. The VECM is accompanied with unit root test which is also called for stationarity test using Augmented Dickey Fuller test (Dickey, 1979) and Johansen Cointegration test. However, the statistical tools applied shall be discussed. It is assumed and it is the basic assumption of econometrics model that the series should be stationary and for VEC model to be applied, the variables should be stationary and there should be cointegration among the variables. VECM which adopt vector autoregressive model focus on endogenous variables and allows the variables in the model to depend on it lag values of order p.

The Var model denoted by Var(p) is mathematically expressed in a general term below as

$y_t = c + A_1y_{t-1} + A_2y_{t-2} + \ldots\ldots + A_py_{t-p} + e_t$ (Gujarati, 2009) and the corresponding VEC model can be written as

$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$ represent GDP Per capita as endogenous and its lag values

$\Delta y_{2,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{2,t}$ represent Ozone as endogenous and its lag values

$\Delta y_{3,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{3,t}$ represent Nitrogen Dioxide as endogenous and its lag values

$\Delta y_{4,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{4,t}$ represent Carbon dioxide and its lag values

where A_1 to A_p are the coefficients of the lag values and Y_{t-1} to Y_{t-p} are the corresponding Lag values and e_t, $\varepsilon_{1,t}$ to $\varepsilon_{3,t}$ is the error term that takes care of all the unaccounted factor in the model (Hill, Griffiths and Lim, 2008).

Var model is the vector autoregressive model that treat all variables either as endogenous and allow it to depend on the lag value p. for your to estimate Var model, first your series have to be stationary of order(1), that is after the first difference or stationary of order (2) then you fit your Lag value and your R-square should be relatively high so as to ensure reliability of your var model.

Multiple regression model

Multiple regression model is fitted to predict Jordan economic growth (GDP Per Capita) with Air pollution variables such as nitrogen dioxide, ozone, and carbon dioxide.

The functional regression model is expressed as;

GDP Per Capita = f (nitrogen dioxide, ozone, and carbon dioxide)

GDP Per Capita = $\beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots\beta_nX_n +$ error term

Where β_1 to β_3 are the coefficient estimates of the air pollution variables (X_1 to X_3 = nitrogen dioxide, ozone, and carbon dioxide).

Granger causality test

For us to investigate the causal relationship of the variables we perform the Granger causality test and mainly focus on the causal relationship among the variables of interest

(Granger, 1987). It can be illustrated hypothetically as X causes Y (X⟶Y) or X is related to Y (X↔Y). This will study whether X causes Y or not. And it pairs each variable for the causality to be examined.

EKC model structure

The EKC hypothesis can be model mathematically as

$$InCo2_{it} = Bo + B_1InGDPPercapita_{it} + B_2(InGDPPercapita_{it})^2 + \mathcal{E}_{it}$$

$$InNo2_{it} = Bo + B_1InGDPPercapita_{it} + B_2(InGDPPercapita_{it})^2 + \mathcal{E}_{it}$$

$$InO3_{it} = Bo + B_1InGDPPercapita_{it} + B_2(InGDPPercapita_{it})^2 + \mathcal{E}_{it}$$

(Ozokcu, 2017)

And can be diagrammatically explained below

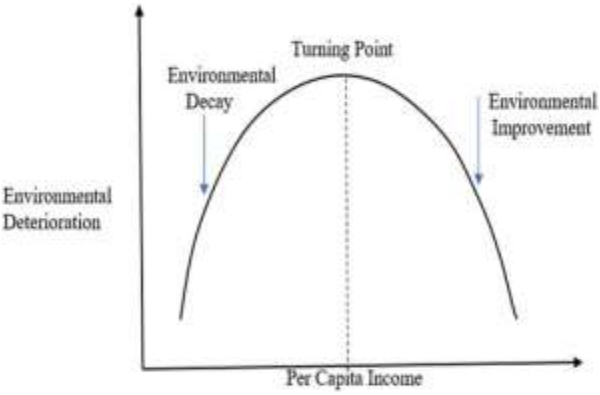

Figure 1: EKC structure

To understand the relationship between environmental quality and income, use the EKC (Song and Tong, 2008).

In the diagram above, the inverse U-shaped hypothesis would be typical. It is environmental degradation, such as carbon dioxide, nitrogen dioxide, and ozone, which is the study's focus. The independent variable is GDP Per capita income.

In the early stages of economic development, a rise in individual income also leads to an increase in individual affluence. The degree of specialization increases until a specific level is reached (the turning point). Continued economic growth brings about a lesser rate of per capita environmental deterioration. This is shown in the above typical EKC diagram a theoretical relationship between degradation per capita and wealth per capita in the shape of the EKC curve indicates whether or not the level of degradation will be maintained as long as the latter is high The EKC hypothesis is thus: In the beginning, economic activity's effect on the resource base tends to lead to a small amount of biodegradable pollution. Resource depletions and waste generation increase alongside industrialization, particularly in agriculture and other extractive and industrial processes, at an accelerating rate. at a more advanced stages of development, structural change to information-intensive industries and services, along with increasing environmental regulations and rising costs, decrease in environmental pollution, whereas low levels of development allow for its gradual pollutant discharge and acceleration and leveling off. Panayotou (1993): After confirming the location of the issue with the help of IT professionals, technicians Many economists contend that if the EKC relationship is true, economic growth is the only way to improve environmental quality. Maddison (2008) notes that, “The best – and probably the only – way to secure a decent environment is to acquire wealth. environmental factors (and income) Before we move on, we need to describe various indicators of environmental degradation. Many pollutants are created as a result of economic production and consumption. Include gases such as carbon dioxide (CO2), nitrogen dioxide (No2) and ozone (O3).

The income level value at which the indicator for environmental degradation E is at a maximum which is expressed as Y* = exp (-B1/2B2) → This is referred to as the Kuznets-Phillips curve (EKC).

Meanwhile, important diagnostic test like normality, and autocorrelation will be performed so as to be sure that the fitted model is robust, valid and reliable.

Result and Interpretation

The data used for this work is secondary data extracted from world bank (https://www.data.worldbank.org), Institute for health metrics and evaluation (IHME) and countryeconomy.com. The statistical software applied is STATA 16.0 and EViews 11.0

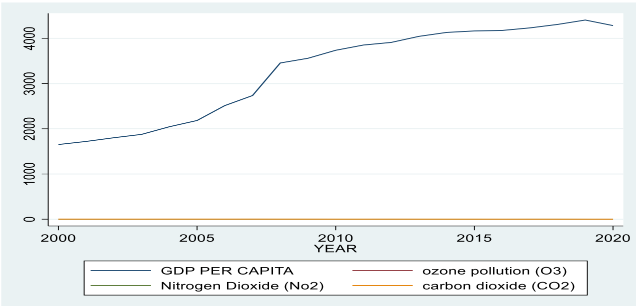

Figure 2: Graph of GDP PER capita, Nitrogen Dioxide, Ozone pollution and Carbon dioxide

Figure 2 shows that gross domestic product per capita which measure the income has the highest growth compare the air pollutants such as ozone pollution, Nitrogen Dioxide and carbon dioxide with lower growth maintaining a constant pattern. This simply means the Jordan economy has sufficiently grow to the extent of keeping environmental pollution low and thereby provide good and healthy environment to the residents of the country.

Table 1: Unit root test with Augmented Dickey fuller test (ADF)

VARIABLES	T-statistic	P-value	Order
Carbon Dioxide	-4.313	0.0037	I (1)
Nitrogen Dioxide	-4.954	0.0011	I (2)
Ozone Pollution	-4.229	0.0044	I (1)
GDP Per capita	-3.070	0.0463	I (1)

Source: Author's calculation using EViews 11.0

From the result of Table 1, we can see that P<0.05 for GDP Per capita means that GDP per capita is integrated of order 1 at 5% level of significance while carbon dioxide and Ozone (P<0.01) are also stationary after the first difference or integrated of order 1 at 1% significant level and P<0.01 for Nitrogen Dioxide means that Nitrogen dioxide is stationary after the second difference or integrated of order 2 at 1% level. This suggest that further empirical analysis can be performed since the series are stationary.

Table 2: Johansen tests for cointegration

Maximum rank	Parameters	Eigenvalues	Trace statistic	5% Critical value
0	20	-	59.65	47.21
1	27	0.845	24.19	29.68
2	32	0.582	7.60	15.41
3	35	0.318	0.32	3.76
4	36	0.017		

Source: Author's calculation using Stata 16.0

Table 3: Cointegrating equation

Equation	Parameters	Chi2 statistic	P-value
_ce1	3	743.338	0.0000

Source: Author's calculation using Stata 16.0

From Table 2 and 3, the cointegration output above using Johansen shows that both the trace and max eigen value is significant at 5% level as the trace statistic (59.65) > critical value (47.21) and P<0.01 for the cointegrating equation. This indicate that there exist a cointegration between air pollution and GDP Per capita being the measure of economic growth and this suggest a long run relationship between air pollution and GDP Per capita. Since there is evidence of cointegration, it suggests fitting of both short run (VAR model) and long run (VECM).

Table 4: Vector Autoregression (short run model)

Equation	Parameters	R-squared	Chi2 statistic	P-value
GDPPERCAPITA	9	0.99	1973.17	0.0000
Ozone Pollution	9	0.78	66.86	0.0000
Nitrogen Dioxide	9	0.98	1096.37	0.0000
Carbon dioxide	9	0.89	156.08	0.0000

Source: Author's Calculation using Stata Software

From the table 4 above we can see that all the model variables (because all are treated as endogenous variable here) and their lags value are statistically significant at 1% level since P<0.01 and this indicate a short run relationship or association between air pollution and GDP Per capita. The R-square is relatively high which implies that the VAR model (vector autoregressive model) is a good fit for the data.

Long run model

Appendix part C show the equation of the vector error correction model (VECM), we can see that parsimonious VECM is achieved with GDP Per capita and Nitrogen dioxide as both are statistically significant at 1% significant level.

Table 5: Granger Causality Wald test

Equation	P-value
GDPPERCAPITA cause ALL	P<0.01
Nitrogen dioxide cause ALL	P<0.01
Carbon dioxide cause ALL	P<0.01

Source: Author's Calculation using Stata Software

Table 5 reveals a Granger causality test output and we can see that GDP Per Capita cause all at 1% level which means GDP PER CAPITA cause ozone pollution, GDP Per Capita cause Nitrogen Dioxide, and GDP Per Capita cause carbon dioxide at 0.01 significant level. This tells us that there is a causal effect of GDP per capita on the three air pollutants under this study. Besides, Nitrogen dioxide and carbon dioxide also cause all at 0.01 significant level.

Table 6: Multiple Regression analysis

Overall regression: Prob>F=0.0000, F (3,17) = 76.32, R-squared = 0.93

GDPPERCAPITA	Coefficient estimate	Test statistic	P-value
Ozone pollution	-1651.85	-1.38	0.185
Nitrogen dioxide	4861.02	8.09	0.000
Carbon dioxide	-888.75	-2.57	0.020
cons	-3816.77	-0.90	0.378

Source: Author's Calculation using Stata Software

From table 6, the regression analysis shows that the overall regression model (P<0.01, F (3,17) =76.32) implies that the model is statistically significant and this implies that there is a significant relationship between economic growth and air pollution variables. R-squared = 0.93% indicate that 93% variation in economic growth of Jordan can be explained by the three Air pollution variables under study. The regression model is significant and R-squared is relatively high which means that the model is adequate and a good fit for the data. Meanwhile, Nitrogen dioxide (P<0.01, β =

4861.02) implies that nitrogen dioxide has a positive significant impact on the Jordan economy while Carbon dioxide ($P<0.05$, $\beta = -888.75$) indicate that carbon dioxide has a negative significant impact on GDP Per capita (Jordan economic growth).

EKC equations

Appendix part C reveal the EKC regression in three stages, we can see from the first EKC equation table that there is a significant relationship between the economic growth and carbon dioxide emission at 1% significant level since the overall regression $P <0.01$. Besides, the economic growth measured by InGDPPerCapita and $InGDPPerCapita^2$ have significant effect on carbon dioxide since their $P <0.01$ and $P <0.01$ respectively.

From the EKC equation in second table in appendix part C, we can see that there is a significant relationship between the economic growth and Nitrogen dioxide at 1% significant level since the overall regression $P = 0.0001<0.01$. Besides, the economic growth measured by InGDPPerCapita and $InGDPPerCapita^2$ have no significant effect on Nitrogen Dioxide since their $P>0.05$ and $P >0.05$ respectively.

From the EKC equation in third table in appendix part C, we can see that the economic growth measured by InGDPPerCapita and $InGDPPerCapita^2$ have significant impact on ozone pollution at 1% level since their $P <0.01$ and $P <0.01$ respectively.

Diagnostic test

Lagrange Multiplier test

Lagrange Multiplier in 4.3.1 above shows that $P > 0.05$ as we can see in appendix part C which indicate that the fitted empirical model does not suffer from autocorrelation problem. Meanwhile, it is important to note that both Var model and VECM are very robust in treating autocorrelation problem.

Test of multicollinearity for OLS regression

We can see that the variance inflation factor (VIF) in appendix part C for all the independent variables are less than 5 which means that the fitted regression model does not suffer from the problem of multicollinearity.

Normality test For OLS regression, Var and VECM models

The above normality test using Shapiro-Wilk, Jarque-Bera, Kurtosis and Skewness test in appendix part C. The P-values are greater than 0.05 significant level (that is, $P > 0.05$) which implies that the variables are normally distributed which satisfy the normality condition and that makes the model more valid, reliable and robust.

Conclusion

Using the Environmental Kuznets Curve (EKC), this study examines the relationship between air pollution and the Jordan economy. Var and VECM also show that air pollution and GDP per capita have a short- and long-term relationship. The Granger causality reveals that GDP per capita has a causal effect on air pollution, indicating that Jordan has developed an optimum capacity to control air pollution, which could pose a health risk and even contribute to a high mortality rate (Hannah, 2019), due to high GDP growth. Meanwhile, urban nitrogen dioxide levels are higher, whereas ozone-induced burdens are frequently more difficult in rural areas. However, the multiple regression analysis reveals that there is a significant relationship between air pollution and economic growth. In this study, three different pollution parameters are used to assess air quality.

The three gases are carbon dioxide (CO_2), nitrogen dioxide (NO_2), and ozone (O_3). They are standard variables in Jordan for regulating air quality. However, the line graph shows that gross domestic product per capita, which measures income, has grown the fastest, while air pollutants like ozone pollution, nitrogen dioxide, and carbon dioxide have grown at a slower rate, maintaining a consistent pattern according to Collivignarelli MC, Abbà A, Bertanza G, Pedraza R, Ricciardi P, Miino MC (2020). This simply means that the Jordan economy has grown sufficiently to keep environmental pollution low and thus provide a good and healthy environment for the country's citizens.

Acknowledgment

I thank God for seeing me through this research work. I am fatherless early in life but I thank God I didn't suffer the pains of the fatherless. My gratitude to my late father and mother for the background that laid for me in the early stage of my life. I want to thank my friend, Twahil Hemed Shakiru for being part of this research and I also want to appreciate Professor Vincent O Akinyosoye, the former director general of the national bureau of statistics in Nigeria. I must thank my wife for her profound commitment to home during this scholarly study.Thank you all and God bless.

References

Ministry of Health. (2006). Statistical Yearbook. Amman, Jordan: Ministry of Health.

IMF. (2001). Government Finance Statistics Manual 2001. Statistics Department

JMD (Jordan Meteorological Department). 2007. Available at http://met.jometeo.gov.jo/ (accessed December 2007).

Hindiyeh M. (2007). "Assessment of Corporate Environmental Responsibility in Jordan." Prepared for UNDP project "Launching the UN Global Compact." United Nations Development Programme. Available online: www.undp-jordan.org/Portals/0/GC%20Environment%20report.doc. Accessed: July 2008.

Government of Jordan. 2005. "National Agenda. Hashemite Kingdom of Jordan." Amman, Jordan. Government of Jordan. 2006a. "Licensing and EIA Guide." Amman, Jordan.

Government of Jordan. 2006b. "National Strategy and Action Plan to Combat Desertification." Amman, Jordan

AFD (Agence Française de Developpement) 2006. "Air Pollution Monitoring in Jordan." Ministry of Environment, Air Quality Monitoring Program. September 2006.

Alawi, M. A., H. Wichmann, W. Lorenz, and M. Bahadir. 1996. "Dioxins and Furans in the Jordanian Environment—Part 2: Levels of PCDD and PCDF in Human Milk Samples from Jordan." Chemosphere 33 (12): 2469–74.

Rhedanz, K., Maddison, D. (2008). Local environmental quality and life-satisfaction in Germany. Ecological Economics 64, 787-797.

Collivignarelli MC, Abbà A, Bertanza G, Pedrazzani R, Ricciardi P, Miino MC (2020) Lockdown for CoViD-2019 in Milan: what are the effects on air quality? Sci Total Environ 732:139280.

EEA (2017) Air quality in Europe — 2017 report, EEA technical report

Gehrsitz M (2017) The effect of low emission zones on air pollution and infant health. J Environ Ecol Manag 83:121–144.

Giesberts L (2018) Diesel-Verkehrsverbote" ausnahmsweise moeglich! NEUE ZEITSCHRIFT FUER VERWALTUNGSRECHT, 37(17).

Qiu G, Song R, He (2019) The aggravation of urban air quality deterioration due to urbanization, transportation and economic development–panel models with marginal effect analyses across China. Sci Total Environ 651:1114–1125.

Zambrano AMA, Broadbent EN, Durham WH (2010) Social and environmental effects of ecotourism in the Osa Peninsula of Costa Rica: the Lapa Rios case. J Ecotour 9(1):62–83.

Rupakheti, M (2015). Air pollution impacts on Agriculture. Institute for Advanced Sustainability Studies (IASS), Potsdam, Germany. Media regional Training, ICIMOD, Kathmandu.

Jalil, Abdul and Feridun, Mete (2011). Long run relationship between income inequality and Financial Development in China: Journal of the Asia Pacific Economy, 16(2),202-214

Hannah, Ritchie and Max, Roser (2019). "State of Global Air". Death rates from Air pollution.

Gujarati, D.N; Porter, D.C (2009). Basic Econometrics (Fifth ed)

Halicioglu, F (2009). An Econometric Study of CO2 Emissions, Energy Consumption, Income and Foreign Trade in Turkey. Energy Policy 2009, 37, 1156–1164.

Johansen,Soren (1991). Estimation and Hypothesis Testing of cointegration vectors in Gaussian vector Autoregressive models. Econometrica. 59(6), 1551-1580.

Dickey, David; Fuller, Wayne. A (1979). Distribution of the estimators for autoregressive time series with a unit root: Journal of the American Statistical association 74(366),427-431.

Ozokcu S, Ozdemir O. (2017). Economic growth, energy, and environmental Kuznets curve. *Renew Sust Energ Rev*. 72:639–47.

Song, T., Zheng, T., and Tong, L. (2008). An empirical test of the environmental Kuznets curve in China: A panel cointegration approach. *China Economic Review* 19, 381–392.

Engle, R. F., and C. W. J. Granger (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica 55(2): 251–276.

Hill, Griffiths and Lim. (2008). Principles of Econometrics, 3rd edition.

Gujarati and Demodar. (2009). Basic Econometrics, International edition.

Panayotou, T (1993). Empirical tests and policy analysis of environmental degradation at different stages of Economic development; working paper, Technology and Employment program; international labor office Geneva, Switzerland.

Ozturk I, Acaravci A. (2020). CO2 emissions, energy consumption and economic growth in Turkey. Renew Sust Energ Rev. 14(9):3220–5.

Marjanovic V, Milovancevic M, Mladenovic I. (2016). Prediction of GDP growth rate based on carbon dioxide (CO2) emissions. J Co2 Util. 16:212–7.

Holtz-Eakin D, Selden TM. (2019). Stoking the Fires—Co2 Emissions and Economic-Growth. J Public Econ. 57(1):85–101

EIA. (2021) International Energy Outlook 2016. Washington, DC

Omer AM. (2019). Energy, environment and sustainable development. Renew Sust Energ Rev.12(9):2265–300.

UNEP. (2018). Decoupling natural resource use and environmental impacts from economic growth.

Kuznets S. (2018). Economic growth and income inequality. The American Economic Review. 45(1):1–28.

Kraft J, Kraft A. (2017) On the Relationship Between Energy and GNP The Journal of Energy and Development. 3(2):401–3.

Akarca AT, Long TV. (2019). On the Relationship between Energy and Gnp—a Reexamination. J Energy Dev. 5(2):326–31

APPENDIX

Part A

Stata commands

tsset YEAR, yearly

twoway (tsline GDPPERCAPITA) (tsline ozonepollutionO3) (tsline NitrogenDioxideNo2) (tsline carbondioxideCO2)
gen lncarbondioxideCO2 = log(carbondioxideCO2)
gen lnozonepollutionO3 = log(ozonepollutionO3)
gen lnNitrogenDioxideNo2 = log(NitrogenDioxideNo2)
gen InGDPPERCAPITA = log(GDPPERCAPITA)
gen InGDPPERCAPITA2 = log(GDPPERCAPITA)*log(GDPPERCAPITA)
vecrank GDPPERCAPITA ozonepollutionO3 NitrogenDioxideNo2 carbondioxideCO2, trend(constant)
var GDPPERCAPITA ozonepollutionO3 NitrogenDioxideNo2 carbondioxideCO2, lags(1/2)
regress GDPPERCAPITA ozonepollutionO3 NitrogenDioxideNo2 carbondioxideCO2
regress lncarbondioxideCO2 InGDPPERCAPITA InGDPPERCAPITA2
regress lnNitrogenDioxideNo2 InGDPPERCAPITA InGDPPERCAPITA2
regress lnozonepollutionO3 InGDPPERCAPITA InGDPPERCAPITA2

Part B

Null Hypothesis: D(CARBON_DIOXIDE__CO2_) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.312512	0.0037
Test critical values:	1% level	-3.831511	
	5% level	-3.029970	
	10% level	-2.655194	

Null Hypothesis: D(GDP_PER_CAPITA) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.069789	0.0463
Test critical values:	1% level	-3.831511	
	5% level	-3.029970	
	10% level	-2.655194	

Null Hypothesis: D(NITROGEN_DIOXIDE__NO2_,2) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.954183	0.0011
Test critical values:	1% level	-3.857386	
	5% level	-3.040391	
	10% level	-2.660551	

Null Hypothesis: D(OZONE_POLLUTION__O3_) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.228957	0.0044
Test critical values:	1% level	-3.831511	
	5% level	-3.029970	
	10% level	-2.655194	

Part C

Johansen tests for cointegration

Trend: constant Number of obs = 19

Sample: 2002 - 2020 Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	20	-37.674275	.	59.6503	47.21
1	27	-19.943867	0.84531	24.1895*	29.68
2	32	-11.650058	0.58232	7.6018	15.41
3	35	-8.0097644	0.31832	0.3213	3.76
4	36	-7.8491335	0.01677		

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	3	743.3384	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
GDPPERCAPITA	1	.	.	.	.	.
ozonepollutionO3	2754.362	1236.859	2.23	0.026	330.163	5178.561
NitrogenDioxideNo2	-3323.727	560.9805	-5.92	0.000	-4423.228	-2224.225
carbondioxideCO2	3165.142	450.1164	7.03	0.000	2282.93	4047.354
_cons	-9110.444	.	.	.	.	.

Vector autoregression

Sample: 2002 - 2020		Number of obs	=	19
Log likelihood =	-7.849134	AIC	=	4.615698
FPE =	.0016503	HQIC	=	4.918547
Det(Sigma_ml) =	.0000268	SBIC	=	6.405162

Equation	Parms	RMSE	R-sq	chi2	P>chi2
GDPPERCAPITA	9	121.327	0.9905	1973.168	0.0000
ozonepollutionO3	9	.051648	0.7787	66.85915	0.0000
NitrogenDioxid~2	9	.025617	0.9830	1096.367	0.0000
carbondioxideCO2	9	.164743	0.8915	156.0818	0.0000

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
GDPPERCAPITA	ozonepollutionO3	3.9213	2	0.141
GDPPERCAPITA	NitrogenDioxide~2	5.7687	2	0.056
GDPPERCAPITA	carbondioxideCO2	3.1577	2	0.206
GDPPERCAPITA	ALL	34.314	6	0.000
ozonepollutionO3	GDPPERCAPITA	3.0236	2	0.221
ozonepollutionO3	NitrogenDioxide~2	1.2393	2	0.538
ozonepollutionO3	carbondioxideCO2	1.3519	2	0.509
ozonepollutionO3	ALL	9.0346	6	0.172
NitrogenDioxide~2	GDPPERCAPITA	33.766	2	0.000
NitrogenDioxide~2	ozonepollutionO3	14.498	2	0.001
NitrogenDioxide~2	carbondioxideCO2	38.15	2	0.000
NitrogenDioxide~2	ALL	58.33	6	0.000
carbondioxideCO2	GDPPERCAPITA	.18807	2	0.910
carbondioxideCO2	ozonepollutionO3	2.7283	2	0.256
carbondioxideCO2	NitrogenDioxide~2	5.3595	2	0.069
carbondioxideCO2	ALL	17.046	6	0.009

Source	SS	df	MS			
				Number of obs	=	21
				F(3, 17)	=	76.32
Model	19568781.9	3	6522927.31	Prob > F	=	0.0000
Residual	1452959.08	17	85468.1813	R-squared	=	0.9309
				Adj R-squared	=	0.9187
Total	21021741	20	1051087.05	Root MSE	=	292.35

GDPPERCAPITA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ozonepollution03	-1651.845	1195.861	-1.38	0.185	-4174.891	871.2001
NitrogenDioxideNo2	4861.019	600.9785	8.09	0.000	3593.065	6128.972
carbondioxideCO2	-888.7543	345.3392	-2.57	0.020	-1617.356	-160.1523
_cons	-3816.771	4219.705	-0.90	0.378	-12719.57	5086.029

VECM (Long run)

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_GDPPERCAPITA	6	156.067	0.6301	22.14805	0.0011
D_ozonepolluti~3	6	.053471	0.1419	2.150597	0.9053
D_NitrogenDiox~2	6	.025842	0.7853	47.55069	0.0000
D_carbondioxid~2	6	.165201	0.4399	10.21092	0.1160

EKC equation (first table)

Source	SS	df MS Number of obs = 21
	F(2, 18) = 29.56	
Model	.263456008	2 .131728004 Prob > F = 0.0000
Residual	.080207129	18 .004455952 R-squared = 0.7666
	Adj R-squared = 0.7407	
Total	.343663137	20 .017183157 Root MSE = .06675
lncarbondioxi~2	Coef.	Std. Err. t P>t [95% Conf. Interval]
InGDPPERCAPITA	13.84759	3.280527 4.22 0.001 6.955458 20.73972
InGDPPERCAPITA2	-.8905082	.2069834 -4.30 0.000 -1.325364 -.4556522
_cons	-52.59861	12.97261 -4.05 0.001 -79.85305 -25.34417

EKC equation (second table)

Source	SS	df MS Number of obs =	21

	F(2, 18) =	88.30	
Model	.065160017	2 .032580008 Prob > F =	0.0000
Residual	.006641158	18 .000368953 R-squared =	0.9075
	Adj R-squared =	0.8972	
Total	.071801175	20 .003590059 Root MSE =	.01921
lnNitrogenDio~2	Coef.	Std. Err. t P>t [95% Conf.	Interval]
InGDPPERCAPITA	-1.417097	.9439719 -1.50 0.151 -3.400309	.5661142
InGDPPERCAPITA2	.0993777	.0595595 1.67 0.113 -.0257522	.2245075
_cons	5.969027	3.732869 1.60 0.127 -1.87344	13.81149

EKC equation (third table)

Source	SS	df MS Number of obs =	21
	F(2, 18) =	45.48	
Model	.021151552	2 .010575776 Prob > F =	0.0000
Residual	.0041858	18 .000232544 R-squared =	0.8348
	Adj R-squared =	0.8164	
Total	.025337352	20 .001266868 Root MSE =	.01525
lnozonepollut~3	Coef.	Std. Err. t P>t [95% Conf.	Interval]
InGDPPERCAPITA	-6.476181	.7494219 -8.64 0.000 -8.050658	-4.901704
InGDPPERCAPITA2	.4109985	.0472844 8.69 0.000 .3116576	.5103395
_cons	26.25646	2.963535 8.86 0.000 20.03031	32.48262

Lagrange Multiplier test

Lagrange	multiplier test	
lag chi2 df	Prob > chi2	
1 16.0392 16	0.45023	
2 12.8021 16	0.68717	
H0: no	autocorrelation at	lag order

Test of multicollinearity for OLS regression

Variable	VIF	
carbondiox~2	3.65	0.274068
NitrogenDi~2	2.27	0.440623
ozonepollu~3	2.09	0.478842
Mean VIF	2.67	

Normality test

Shapiro-Wilk	W	test for	3	parameter	Lognormal data
Variable	Obs	W	V	z	Prob>z
GDPPERCAPITA	21	0.83745	3.983	-2.038	0.97923
ozonepollu~3	21	0.94566	1.332	1.311	0.09488
NitrogenDi~2	21	0.93762	1.529	1.623	0.05231
carbondiox~2	21	0.95570	1.086	0.893	0.18598

Jarque-Bera test

Equation	chi2	df	Prob > chi2
GDPPERCAPITA	2.069	2	0.35533
ozonepollutionO3	0.446	2	0.80016
NitrogenDioxideNo2	0.730	2	0.69436
carbondioxideCO2	0.176	2	0.91562
ALL	3.421	8	0.90522

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
GDPPERCAPITA	.44402	0.624	1	0.42944
ozonepollutionO3	.08875	0.025	1	0.87451
NitrogenDioxideNo2	-.16699	0.088	1	0.76635
carbondioxideCO2	-.18722	0.111	1	0.73901
ALL	0.849	4	0.93182	

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
GDPPERCAPITA	4.3511	1.445	1	0.22931
ozonepollutionO3	2.2708	0.421	1	0.51647
NitrogenDioxideNo2	2.1	0.641	1	0.42327
carbondioxideCO2	2.7128	0.065	1	0.79828
ALL	2.573	4	0.63168	