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Air pollution, health expenditure and economic growth in MINT countries: a trivariate causality test

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Abstract

Purpose – This paper examines the long-run and dynamic causal relationship among air pollution, health expenditure and economic growth in Mexico, Indonesia, Nigeria and Turkey (MINT countries).

Design/methodology/approach – The bounds test approach to cointegration and causality test was employed on data covering 1995–2018.

Findings – The study shows evidence of a long-run relationship among the variables in MINT countries and the causality test confirms the existence of a bidirectional causal nexus between health expenditure and economic growth in the four countries. It also confirms that there is a bidirectional causal relationship between carbon dioxide (CO_2) emission and economic growth, except in Nigeria where a unidirectional causal relationship was found running from CO_2 emissions to economic growth. In addition, a bidirectional causal relationship was found between air pollution and health expenditure in Turkey, while no causal relationship was found among these variables in Nigeria.

Research limitations/implications – This study is limited by available data and it only focuses on four emerging economies. To address this, future studies can expand this scope to more emerging economies with severe air pollution and also extend the scope when more recent data becomes available.

Practical implications – This study suggests that pollution standards in MINT countries should be monitored and enforced with transparency so as to mitigate its health implications and ensure the sustainability of economic growth.

Social implications – The study confirms the importance of keeping air pollution as low as possible because of its negative effect on health and economic output.

Originality/value – The study accounts for the complexity of each MINT country instead of providing a general discussion on the relationship between air pollution, health expenditure and economic growth in MINT countries.

Keywords Air pollution, Health expenditure, Economic growth, MINT countries

Paper type Research paper

1. Introduction

Air pollution largely triggered by increased energy consumption and production is globally considered a major environmental risk to health and sustainable development. This deterioration of air quality has significant economic consequences at all levels. It adversely impacts agricultural products and labor productivity; it is associated with increased morbidity and mortality which affects health expenditures; and it accounts for an estimated 6.5 million deaths annually (International Energy Agency (IEA), 2016). In addition, pollution from fossil fuels confers an economic cost of US$8bn daily and an estimated 4.5 million premature deaths (Myllyvirta, 2020).

The hypothesized relationship between air pollution and economic growth is explained by the environmental Kuznets curve (EKC). This shows that initial pressures caused by

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economic development and a rise in per capita income lead to an increase in pollution and a decline in environmental quality. The trend, however, reverses as the pressure declines, such that, further increases in income beyond a certain point leads to improvements in environmental quality (Grossman and Krueger, 1995). Health, on the other hand, is considered a durable capital stock which increases productivity in the market and nonmarket sectors (Grossman, 1999), thus increasing income per capita and economic growth. Based on these theories that explain the direct and indirect welfare effect of air pollution on human health and per capita income, exploring the relationship between them is vital to the achievement of sustainable development.

In 2011, Mexico, Indonesia, Nigeria and Turkey (MINT countries) were classified together as emerging countries due to similar economic, geographic and demographic factors. These countries enjoyed rapid population, industrial and economic growth over the years but recent evidence (Odugbesan and Rjoub, 2020; Agbede *et al.*, 2021) suggest that their development is at a cost to the environment, particularly a decrease in air quality. For instance, in 2019, Nigeria and Indonesia were ranked among the top five countries in the world with the highest pollution deaths (Fuller *et al.*, 2019); Mexico, Turkey and Indonesia were ranked among the top 20 countries with the largest carbon dioxide (CO_2) emissions (Friedrich *et al.*, 2020) and the report for global air quality (IQAir, 2020) rates Indonesia among the ten most polluted countries (using PM2.5 concentration) due to agricultural burning of cropland and wildfires.

Empirical evidence initially focused on establishing a nexus between health expenditure and economic growth, air pollution and economic growth, or between air pollution and health expenditure because of their theoretical link. The first group centered on the health–growth nexus and they identified growth as a major driver of health expenditure (Murthy and Okunade, 2016; Akca *et al.*, 2017), while others (Amiri and Ventelou, 2012; Halıcı-Tülüce *et al.*, 2015; Barkat *et al.*, 2019) established a bilateral relationship between growth and pollution. The second group of studies established the connection between air pollution and economic growth by examining the U-shaped hypothesis (He and Richard, 2010; Apergis and Ozturk, 2015; Stern, 2017). Meanwhile, the third strand of literature provides empirical evidence indicating a positively significant relationship between air pollution and health-care cost/spending (Yahaya *et al.*, 2016; Yang and Zhang, 2018; Chen and Chen, 2021).

Based on the aforementioned, air pollution poses a major health risk to humans and it can negatively impact productivity as well as economic growth. Recent studies modeling the nexus among air pollution, health expenditure and economic growth (Yazdi and Khanalizadeh, 2017; Ibukun and Osinubi, 2020; Bilgili *et al.*, 2021) are increasingly providing evidence of a short-run effect, long-run effect or nonlinear effect; but empirical discussion on the direction of causality is mixed (Chaabouni *et al.*, 2016; Mujtaba and Shahzad, 2021; Zaidi and Saidi, 2018) and it does not capture emerging economies.

This study, therefore, adds to the body of literature by assessing the causal relationship between air pollution, health expenditure and economic growth in MINT countries. Unlike previous studies, it adopts a country-specific approach instead of a panel approach and the aim is to capture and account for the complexity of each country rather than providing a general discussion on them. The rest of this paper is structured as follows. Section 2 presents a review of the literature. Section 3 describes the data and methodology used. Section 4 presents the results of the empirical analysis with section 5 showing the conclusion.

2. Literature review

Over the past decades, an extant empirical discussion has focused on the causal relationship between health expenditure and economic growth or between air pollution and economic growth, with very limited studies examining the causal relationship between air pollution, health expenditure and economic growth. Where such studies are conducted, findings have been mixed or inconclusive. Some confirmed the bilateral hypothesis, while others asserted a unilateral hypothesis or the neutrality hypothesis. Therefore, the preceding paragraphs of this section will discuss the causal relationship among these variables given the various dimensions.

2.1 Health expenditure and economic growth

Following the human capital theory and the endogenous growth models, the nexus between health expenditure and economic growth has been widely researched (Aslan *et al.*, 2016; Ibukun, 2021), although there have been mixed findings when the direction of causality is discussed. For instance, in 2012, Amiri and Ventelou provided general evidence of bidirectional causality between health expenditure and economic growth in 20 Organisation for Economic Co-operation and Development (OECD) countries after applying the Toda-Yamamoto approach. Halıcı-Tülüce *et al.* (2015) whose study applied a different method (dynamic panel approach) to 25 high-income countries and 19 low-income countries also confirmed the existence of a bilateral nexus. While revisiting this issue, Hsiao's version of Granger causality was applied by Amiri and Linden (2015) to 22 OECD countries and their study like Amiri and Ventelou (2012) and Halıcı-Tülüce *et al.* (2015) asserted predominant evidence of a two-way causality between economic growth and health expenditure.

Different from the method applied by the above-mentioned studies, Aslan *et al.* (2016) investigated the long-run and causal relationship between health expenditure and economic growth in the G7 countries using two approaches (Toda–Yamamoto and Hatemi-J). Their findings on data covering 1980–2009 confirmed the evidence of bidirectional causality between the variables in all the countries. Also applying a different method (linear and a nonlinear Granger causality), Ye and Zhang (2018) focused on 15 OECD countries and five major developing countries, and like Aslan *et al.* (2016) a country-specific analysis was conducted. Evidence from this study, however, showed no causal relationship between these variables in Australia, UK and Austria; a linear causal relationship running from economic growth to health-care expenditure in India, Ireland, Portugal and Korea and a two-way linear causality in South Africa, Canada, Brazil, Finland, Spain, Iceland and New Zealand. Additionally, a recent finding by Esen and Çelik Keçili (2021) confirmed the existence of a long-run relationship and unidirectional causality from health expenditure to economic growth in the short run.

In summary, the majority of the studies reviewed above confirm a bilateral causal nexus between health expenditure and economic growth. That is, the relationship between health expenditure and economic growth can be explained in both directions since the previous studies establish the existence of the growth-led health hypothesis and/or the health-led growth hypothesis.

2.2 Air pollution and economic growth

Following the EKC hypothesis that established a significant relationship between air pollution and economic growth, different studies have emerged over the years with the intent of establishing or nullifying the hypothesis. For example, Apergis *et al.* (2020) supports the hypothesis using panel data of 14 Asian countries, while He and Richard (2010) found little evidence of the hypothesis. In terms of causality, an empirical investigation of 12 sub-Saharan African countries (Esso and Keho, 2016) confirmed a one-way causal relationship running from economic growth to air pollution in Ghana, Benin, Senegal and the Democratic Republic of Congo; a reverse causality from air pollution to economic growth in Gabon and Togo but a short-run bidirectional causality between these two variables in Nigeria. Similarly, a study on the G7 countries (Bildirici and Gökmenoğlu, 2017) found a general unidirectional Granger causality from CO_2 emissions to economic growth; while another study on 11 Central and Eastern European countries (Stefan *et al.*, 2019) showed a one-way causal relationship running from economic growth to air pollution in the short run, but the reverse in the long run.

Other studies such as Ghorashi and Rad (2017), Zaidi and Saidi (2018) and Erdoğan *et al.* (2019) reported a bilateral relationship between the two variables; however, Gorus and Aydin (2019) and Chontanawat (2020) found no causal relationship between air pollution and economic growth in the Middle East and North African (MENA) countries and in ASEAN countries, respectively. More recently, Odugbesan and Rjoub (2020) focused on MINT countries. Their study established a bidirectional relationship between economic growth and air pollution in Mexico, and a unidirectional long-run relationship running from air pollution to economic growth in Turkey. The study, therefore, notes that it is important to implement air pollution–reducing policies in Turkey since it will be detrimental to growth.

In summary, many studies reviewed in this subsection confirm an association between air pollution and economic growth. However, empirical evidence regarding their direction of causality is mixed and it varies across different countries.

2.3 Air pollution and health expenditure

The health effect of air pollution has been of interest to many researchers particularly because of the negative effect of fossil fuels on climate change and its trickle-down effect on health. Where economists are most concerned is the effect or interaction of these two variables with sustainable economic growth globally. Hence, the vast majority of causality studies here focus on air pollution, health expenditure and economic growth, although the studies centered on different countries, methods and findings.

From a global perspective, Chaabouni *et al.* (2016) implemented dynamic simultaneous equations in examining the causal nexus among CO_2 emissions, health expenditure and economic growth. Here, the countries were classified into three categories: upper-middle-income countries, lower-middle-income countries and low-income countries. Their findings suggest a bidirectional causal relationship between air pollution and health expenditure in low-income countries, but a one-way causal relationship running from CO_2 emissions to health expenditure in other countries. Similarly, a panel study by Sileem (2016) which centered on 19 MENA economies asserted a two-way causality between air pollution and health expenditure, even though the study unlike Chaabouni *et al.* (2016) accounted for the effect of corruption instead of growth.

Using the Toda–Yamamoto method, Atay and Ergun (2018) found a unidirectional causal relationship running from health expenditure to CO_2 emissions in Turkey; from health expenditure to economic growth and from economic growth toward CO_2 emissions. Meanwhile, Zaidi and Saidi (2018), whose study applied a panel VECM approach to sub-Saharan African countries, discovered a two-way causal relationship between health expenditure and air pollution in line with Chaabouni *et al.* (2016) and Sileem (2016).

In addition to the earlier mentioned studies, Wang *et al.* (2019) also applied a vector error correction model (VECM) to 18 OECD countries between 1975 and 2017. A study by Chaabouni *et al.* (2016) had various findings, one of which is a bidirectional causal relationship between health expenditure and CO_2 emissions in New Zealand and Norway. Similarly, Mujtaba and Shahzad (2021) focused on 28 OECD countries between 2002 and 2018 and their study confirmed the existence of a bilateral nexus between air pollution and health-care spending. This is slightly different from a recent study on 20 Asian countries (Nasreen, 2021) which confirmed a one-way causal nexus flowing from air pollution to health expenditure.

Summarily, the vast majority of the studies that discussed the relationship between the three variables of interest suggest the existence of a bilateral relationship between air pollution and economic growth (Chaabouni *et al.*, 2016; Ghorashi and Rad, 2017), between health expenditure and economic growth (Amiri and Ventelou, 2012; Aslan *et al.*, 2016) and between air pollution and health expenditure for various countries (Wang *et al.*, 2019; Ganda, 2021), despite the diverse methods employed by these scholars. This study, however, employs a trivariate causality approach in examining this relationship, while focusing on MINT countries.

3. Methodology

3.1 Data

This study uses annual data centered on MINT countries. A country-specific analysis is preferred in order to understand the objective of the study in the four countries, given their peculiar characteristics. For the measurement of air pollution, in line with other studies (Chaabouni and Saidi, 2017; Yazdi and Khanalizadeh, 2017; Ibukun and Osinubi, 2020), CO_2 emission in kilo tons is utilized and the data was obtained from the World Bank's, World Development Indicators (WDI, 2021). Economic growth, measured by gross domestic product (GDP) per capita (constant 2010 USD) was also retrieved from WDI (2021), while the total health expenditure of each country was sourced from the OECD database (OECD, 2021) and WDI (2021). The data utilized spanned between 1995 and 2018; all missing values in the dataset were derived by linear extrapolation/interpolation, and the data were transformed into a natural logarithm for estimation purposes.

In this study, we examine how air pollution, health expenditure and economic growth are related in the long run, and we also focus on the dynamic causal relationship among the three. This is because causality studies based on a bivariate framework may be unreliable and the introduction of a third variable can alter both the magnitude of the estimates and the inference drawn (Odhiambo, 2009; Esso and Keho, 2016). To begin, the order of integration of the data series is tested using the Philip–Perron and GLS unit root test. Thereafter, the test for cointegration among the variables is conducted, and then, causality tests are performed to check the direction of causality among them.

3.2 Cointegration test

To test for a long-run relationship among the variables of interest, the bounds testing approach of Pesaran *et al.* (2001) is used. This approach unlike other cointegration approaches, such as Engle and Granger (2015), Johansen and Juselius (1990) and Johansen (1988), is preferred because of its small sample properties. Second, the autoregressive distributed lag (ARDL) procedure is applicable irrespective of the stationarity properties of the regressors. That is, they could be stationary at level, $I(0)$, or at the first difference, $I(1)$, and the unit root testing is only required to establish that the regressors are not integrated of any order greater than 1. The procedure also allows the variables to have different optimal lags, which is impossible with conventional procedures.

The bounds test involves the estimation of Equation (1), an unrestricted error correction model, by ordinary least squares.

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta CO_{2t-i} + \sum_{i=0}^{p} \delta_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{m} \varphi_{1i} \Delta HE_{t-i} + \lambda_1 CO_{2t-1} + \lambda_2 GDP_{t-1} + \lambda_2 HE_{t-1} + \nu_t \tag{1}$$

where Δ is the first difference operator and ν_t is the white noise term. In Equation (1), each variable serves as the regressand; β, δ and φ are coefficients; while n, p and m are the optimal lag orders selected based on a criterion such as Akaike Information Criterion. The bounds testing procedure is based on the joint F-statistics that is tested on the null of no cointegration. If the calculated F-statistics falls above the upper band critical value, $I(1)$, the null is rejected and cointegration is established; otherwise, the null hypothesis of no cointegration is accepted. However, if it falls between the bounds, the order of integration of the underlying regressors will be required.

3.3 Causality test

The ARDL cointegration approach does not indicate the direction of causality; it only tests whether or not a long-run relationship exists among the variables. If cointegration exists among the variables, a temporal relationship among the variables is modeled within a dynamic error correction representation and the error correction term is incorporated (Engle and Granger, 2015; Esso and Keho, 2016). Hence, the trivariate Granger causality model of air pollution, economic growth and health expenditure based on the error-correction mechanism can be expressed as follows:

$$\Delta GDP_t = \alpha_1 + \sum_{j=1}^{n} \delta_{1j}\Delta GDP_{t-j} + \sum_{j=1}^{n} \beta_{1j}\Delta CO_{2t-j} + \sum_{j=1}^{n} \varphi_{1j}\Delta HE_{t-j} + \lambda_1 ECT_t + \zeta_{1t} \quad (2)$$

$$\Delta CO_{2t} = \alpha_2 + \sum_{j=1}^{n} \delta_{2j}\Delta GDP_{t-j} + \sum_{j=1}^{n} \beta_{2j}\Delta CO_{2t-j} + \sum_{j=1}^{n} \varphi_{2j}\Delta HE_{t-j} + \lambda_2 ECT_t + \zeta_{2t} \quad (3)$$

$$\Delta HE_t = \alpha_3 + \sum_{j=1}^{n} \delta_{3j}\Delta GDP_{t-j} + \sum_{j=1}^{n} \beta_{3j}\Delta CO_{2t-j} + \sum_{j=1}^{n} \varphi_{3j}\Delta HE_{t-j} + \lambda_3 ECT_t + \zeta_{3t} \quad (4)$$

where ECT_{t-1} represents the lagged error correction term obtained from the long-run cointegrating relationship. If there is no cointegration, Equations (2)–(4) will reduce to a vector autoregressive (VAR) model in first difference, and the error correction term which helps to differentiate between the short-run and long-run Granger causality will not be included. Here, Granger causality can be explained in two ways: the short-run causal impact is obtained by testing the significance of the lagged dynamic terms and the F-statistics, while the long-run causal impact is measured by testing the significance of the coefficient of the error correction term. Following Equations (2)–(4), the following causal relationship can be obtained among air pollution, economic growth and health expenditure.

Causal flow		Conditions
1	Air pollution (CO_2) → Economic growth (GDP)	$\beta_{1j} \neq 0;\ \lambda_1 \neq 0$
2	Economic growth (GDP) → Air pollution (CO_2)	$\delta_{2j} \neq 0;\ \lambda_2 \neq 0$
3	Health exenditure (HE) → Economic growth (GDP)	$\varphi_{1j} \neq 0;\ \lambda_1 \neq 0$
4	Economic growth (GDP) → Health exenditure (HE)	$\delta_{3j} \neq 0;\ \lambda_3 \neq 0$
5	Health exenditure (HE) → Air pollution (CO_2)	$\varphi_{2j} \neq 0;\ \lambda_2 \neq 0$
6	Air pollution (CO_2) → Health exenditure (HE)	$\beta_{3j} \neq 0;\ \lambda_3 \neq 0$

4. Empirical result and discussion

In this section, empirical evidence of the long-run and causal relationship among air pollution, health expenditure and per capita economic growth in MINT countries are provided. To analyze the dataset, a unit root test on all the variables are conducted, followed by a cointegration test and causality test.

The unit root estimations of Phillips–Perron (Phillips and Perron, 1988) and DF-GLS (Elliott *et al.*, 1996) were used to test if the variables were stationary at level or first difference. This is done to ensure the robustness of the results. Table 1 shows that across MINT countries, all the variables contain unit roots and they become stationary after first differencing. That is, all the variables used in this study are integrated of order one.

Following this, the bounds test for cointegration among the variables is conducted to check whether there is a long-run relationship among them. A maximum lag length of 4 is selected due to the small number of observations and the general-to-specific approach is used to select the appropriate lag. The result of the bounds test presented in Table 2 provides evidence of a long-run relationship between air pollution, health expenditure and economic growth. Here, the F-statistics for all the equations is greater than the 10% critical value, which allows the rejection of the null hypothesis of no cointegration, except for Nigeria when CO_2 is made the dependent variable. Hence, the three variables do not move far from each other in the long run.

In Table 3, the long-run relationship existing among the variables is presented because cointegration has been established. As shown in the table, health expenditure positively

Country	Level GDP	Level HE	Level CO_2	First difference GDP	First difference HE	First difference CO_2
Philips–Perron unit root test						
Mexico	−2.4835	2.4984	−1.4755	−4.0307*	4.3168*	−6.3160*
Indonesia	0.9410	−2.2111	0.1465	−3.6841*	−7.4976*	−7.2011*
Nigeria	−0.8637	−2.0358	−2.4266	−2.1717	−5.9416*	−4.6245*
Turkey	0.0695	−1.0472	−0.2596	−4.3821*	−5.8714*	−3.7698*
DF-GLS unit root test						
Mexico	−0.9003	−1.2196	−1.2774	−3.6254*	−5.3425*	−3.4186*
Indonesia	0.5271	−0.9049	−0.2759	−3.6149*	−7.6633*	−4.6710*
Nigeria	−0.9016	−0.8908	−1.2744	−2.1935*	−5.8549*	−4.7319*
Turkey	0.5031	−0.1494	0.3093	−4.4327*	−2.2250*	−5.2881*

Note(s): The critical values for Philips–Perron at 5% level are −2.9981 at level and 3.0049 at first difference. For the DF-GLS test, the critical values at 5% are 1.9564 at level and −1.9572 at first difference. * denotes the acceptance of the null hypothesis of the presence of unit root at 5% level. CO_2, carbon dioxide; GDP, gross domestic product; HE, health expenditure

Table 1.
Results for unit root estimation

Country	GDP	HE	CO_2	Cointegration?
Mexico	4.8857***	7.0643**	3.6829*	Yes
Indonesia	15.3262***	10.1096**	4.5294**	Yes
Nigeria	4.0668**	7.5652***	1.9071	Yes
Turkey	7.3671***	9.0254***	5.8802***	Yes

Critical values bound 5%		10%	
$I(0)$	$I(1)$	$I(0)$	$I(1)$
3.1	3.87	2.63	3.35

Note(s): *, ** and *** denote the rejection of the null hypothesis at the 10%, 5% and 1% significance levels, respectively. Lags included in equations are in parenthesis (); CO_2, carbon dioxide; GDP, gross domestic product; HE, health expenditure

Table 2.
Cointegration result using bounds test

Country	Dependent Variable	GDP	HE	CO_2
Mexico	GDP	–	0.2317 [2.3601]**	−1.1637 [−3.5809]*
	HE	−0.6079 [0.5399]	–	0.3476 [0.7259]
	CO_2	−0.7665 [−1.6554]	0.3241 [5.1551]*	–
Indonesia	GDP	–	0.3852 [3.9534]*	0.3834 [1.8473]**
	HE	1.9533 [7.1786]*	–	−0.3166 [−1.2006]
	CO_2	0.6446 [2.3541]*	0.2483 [2.0912]*	–
Nigeria	GDP	–	−1.1478 [−0.6992]	1.5612 [1.0155]
	HE	0.4161 [1.6448]	–	0.6843 [4.7840]*
Turkey	GDP	–	−0.3805 [−2.9393]*	1.2601 [7.5224]*
	HE	1.7239 [2.853]*	–	2.6050 [4.9015]*
	CO_2	0.7250 [7.4610]*	0.3252 [4.4467]*	–

Note(s): Figures are coefficients and the *t*-statistics are presented in parenthesis [ ]. * and ** denote the rejection of the null hypothesis at the 5% and 10% significance levels, respectively; CO_2, carbon dioxide; GDP, gross domestic product; HE, health expenditure

Table 3.
Long-run estimates

contributes to economic growth in Indonesia and Turkey in line with Atilgan *et al.* (2017), and Esen and Çelik Keçili (2021) and it plays a significant role in the economic growth process. The findings also suggest that in the long run, increases in real GDP tend to increase health expenditure, and this is in agreement with the findings of Yazdi and Khanalizadeh (2017). Similarly, CO_2 emissions are found to be positively associated with economic growth in Indonesia, and Turkey. That is, the economic expansions of these countries are associated with an increase in air pollution; hence, a need to reduce the emission of pollutants without negatively influencing economic growth. In addition, Table 3 shows that health expenditure increases air pollution in Nigeria and Turkey, while air pollution increases health expenditure in Mexico, Indonesia and Turkey, in line with Mujtaba and Shahzad (2021). It is therefore important for MINT countries to adopt environmental policies that will aid the reduction of health illnesses affiliated with air quality.

Having established cointegration among air pollution, health expenditure and economic growth, the direction of causality among the variables is examined using the ECM based causality test presented in Table 4. In the short run, the result shows that health expenditure Granger causes economic growth in MINT countries; while economic growth causes health expenditure in all the countries except Indonesia. Hence, a bilateral causal relationship between health expenditure and economic growth is predominant, in agreement with the findings of Amiri and Ventelou (2012), Halıcı-Tülüce *et al.* (2015) and Amiri and Linden (2015). The implication is that as health expenditure increases, the economics of scale gets better and it stimulates economic growth, while an increase in economic growth can expand the frontier for health expenditure since health is fundamental to sustainable development.

Regarding air pollution, the results show a bidirectional causal relationship between CO_2 emissions and economic growth in Mexico, Indonesia and Turkey. This suggests a mixture of consumption and production types of the causal relationship between GDP and air pollution in agreement with the findings of Barassi and Spagnolo (2012), Zaidi and Saidi (2018) and Odugbesan and Rjoub (2020). Furthermore, this study found a one-way causal relationship running from CO_2 to real GDP in Nigeria, which suggests that technological advancement in the country is linked with economic growth. It is, therefore, important for Nigeria to make use of technology that promotes environmental protection because of its long-run effect.

Table 4 further shows no short-run causal relationship between air pollution and health expenditure in Nigeria, a unidirectional causal effect running from health expenditure to air

Table 4.
Result of causality test

Country	Short-run causality HE → GDP	CO_2 → GDP	GDP → HE	CO_2 → HE	HE → CO_2	GDP → CO_2
Mexico	1.8196** (0.0966)	3.7729** (0.0889)	6.4244* (0.0249)	0.0017 (0.9678)	2.4054* (0.0286)	2.9078** (0.0668)
Indonesia	5.1713* (0.0287)	3.3289** (0.0780)	1.6268 (0.2226)	−0.1896 (0.2026)	3.3072** (0.0866)	4.2032** (0.0561)
Nigeria	7.9354* (0.0137)	5.0548* (0.0223)	3.7132* (0.0498)	1.4123 (0.2961)	0.3371 (0.7199)	0.4270 (0.6613)
Turkey	5.8538* (0.0111)	13.2332* (0.0054)	3.4936* (0.0496)	12.1059* (0.0069)	4.3726* (0.0324)	4.5612* (0.0290)

Country	Long-run causality GDP	HE	CO_2
Mexico	−1.3875 [−4.0398]*	−0.2446 [−5.8973]*	−0.4553 [−4.1825]*
Indonesia	−0.0817 [−8.9273]*	−0.5990 [−7.0074]*	−0.9818 [−4.6168]*
Nigeria	−0.0657 [−4.4450]*	−0.9385 [−6.2721]*	−0.7011 [1.2460]
Turkey	−0.5894 [−9.6241]*	−0.4333 [−6.9380]*	−0.8518 [−5.6869]*

Note(s): Statistics presented for the short run are F-statistics and the figures in parenthesis ( ) are p-values, while the ones presented for the long run are coefficients on ECT_{t-1} and the figures in square brackets [ ] are their t-statistics. * and ** denote statistical significance at the 5% and 10% levels respectively; CO_2, carbon dioxide; GDP, gross domestic product; HE, health expenditure pollution in Mexico and Indonesia, but a bidirectional relationship between the two variables is found for Turkey. Hence, the causal nexus between air pollution and health expenditure varies among countries.

Focusing on the long-run causality, the findings of this study reinforce the existence of a long-run relationship between air pollution, health expenditure and economic growth in MINT countries. That is, alongside Chaabouni *et al.* (2016) and Wang *et al.* (2019), air pollution and health expenditure jointly cause economic growth; real GDP per capita and air pollution jointly cause health expenditure and air pollution is jointly caused by economic growth and health expenditure in the long run, except for Nigeria. In addition, the diagnostic test on the residuals confirms no evidence of serial correlation and heteroscedasticity for each equation, while the CUSUM and CUSUM of squares (in Appendix) confirm their stability.

5. Conclusion

This study examined the causal relationship between air pollution, health expenditure and economic growth in MINT countries. Different from previous studies that used a bivariate causality model which may suffer from omitted variable bias, this study made use of a simple trivariate causality framework that incorporates the three variables. The empirical result confirmed the existence of a bidirectional causal relationship between health expenditure and economic growth in the four countries both in the long and short run; it also confirms that there is a bidirectional causal relationship between CO_2 emission and economic growth, except in Nigeria where a unidirectional causal relationship was found running from CO_2 emissions to economic growth. In addition, no causal relationship was found between air pollution and health expenditure in Nigeria, and a bidirectional relationship was found among these variables in Turkey. By implication, air pollution and health expenditure are contemporary issues that affect the economic performance of MINT countries. Hence, the countries should adopt health and environmental policies that will minimize the emission of pollutant gases, protect environmental quality and improve the health of the population, so that, economic growth will not be attained at the expense of the environment and public health.

In terms of limitation, this study only focused on four emerging economies which limits the scope of its findings. To address this, future studies can expand this scope to more emerging economies with severe air pollution.

References

Agbede, E.A., Bani, Y., Azman-Saini, W.N.W. and Naseem, N.A.M. (2021), "The impact of energy consumption on environmental quality: empirical evidence from the MINT countries", *Environmental Science and Pollution Research*, Vol. 2021, pp. 1-20, doi: 10.1007/S11356-021-14407-2.

Akca, N., Sonmez, S. and Yilmaz, A. (2017), "Determinants of health expenditure in OECD countries: a decision tree model", *Pakistan Journal of Medical Sciences*, Vol. 33 No. 6, p. 1490, doi: 10.12669/PJMS.336.13300.

Amiri, A. and Linden, M. (2015), "Income and total expenditure on health in OECD countries: evidence from panel data and Hsiao's version of Granger non-causality tests", *Economics and Business Letters*, Vol. 5 No. 1, p. 1, doi: 10.17811/ebl.5.1.2016.1-9.

Amiri, A. and Ventelou, B. (2012), "Granger causality between total expenditure on health and GDP in OECD: evidence from the Toda–Yamamoto approach", *Economics Letters*, Vol. 116 No. 3, pp. 541-544, doi: 10.1016/J.ECONLET.2012.04.040.

Apergis, N. and Ozturk, I. (2015), "Testing environmental Kuznets curve hypothesis in Asian countries", *Ecological Indicators*, Vol. 52, pp. 16-22, doi: 10.1016/J.ECOLIND.2014.11.026.

Apergis, N., Bhattacharya, M. and Hadhri, W. (2020), “Health care expenditure and environmental pollution: a cross-country comparison across different income groups”, *Environmental Science and Pollution Research*, Vol. 27 No. 8, pp. 8142-8156, doi: 10.1007/s11356-019-07457-0.

Aslan, A., Menegaki, A.N. and Tugcu, C.T. (2016), “Health and economic growth in high-income countries revisited: evidence from an augmented production function for the period 1980–2009”, *Quality and Quantity*, Vol. 50 No. 2, pp. 937-953, doi: 10.1007/S11135-015-0184-2.

Atay, P.M. and Ergun, S. (2018), “The relationship between economic growth, CO2 emissions and health expenditures in Turkey under structural breaks”, *Business and Economics Research Journal*, Vol. 9 No. 3, pp. 481-497, available at: https://ideas.repec.org/a/ris/buecrj/0339.html

Atilgan, E., Kilic, D. and Ertugrul, H.M. (2017), “The dynamic relationship between health expenditure and economic growth: is the health-led growth hypothesis valid for Turkey?”, *European Journal of Health Economics*, Vol. 18 No. 5, pp. 567-574, doi: 10.1007/s10198-016-0810-5.

Barassi, M.R. and Spagnolo, N. (2012), “Linear and non-linear causality between CO_2 emissions and economic growth linear and non-linear causality between C02 emissions and economic growth”, *Source: The Energy Journal*, Vol. 33 No. 3, pp. 23-38.

Barkat, K., Sbia, R. and Maouchi, Y. (2019), “Empirical evidence on the long and short run determinants of health expenditure in the Arab world”, *The Quarterly Review of Economics and Finance*, Vol. 73, pp. 78-87, doi: 10.1016/J.QREF.2018.11.009.

Bildirici, M.E. and Gökmenoğlu, S.M. (2017), “Environmental pollution, hydropower energy consumption and economic growth: evidence from G7 countries”, *Renewable and Sustainable Energy Reviews*, Vol. 75, pp. 68-85, doi: 10.1016/J.RSER.2016.10.052.

Bilgili, F., Kuşkaya, S., Khan, M., Awan, A. and Türker, O. (2021), “The roles of economic growth and health expenditure on CO2 emissions in selected Asian countries: a quantile regression model approach”, *Environmental Science and Pollution Research*, Vol. 2021, pp. 1-24, doi: 10.1007/S11356-021-13639-6.

Chaabouni, S. and Saidi, K. (2017), “The dynamic links between carbon dioxide (CO2) emissions, health spending and GDP growth: a case study for 51 countries”, *Environmental Research*, Vol. 158 August 2016, pp. 137-144, doi: 10.1016/j.envres.2017.05.041.

Chaabouni, S., Zghidi, N. and Ben Mbarek, M. (2016), “On the causal dynamics between CO2 emissions, health expenditures and economic growth”, *Sustainable Cities and Society*, Vol. 22, pp. 184-191, doi: 10.1016/j.scs.2016.02.001.

Chen, F. and Chen, Z. (2021), “Cost of economic growth: air pollution and health expenditure”, *Science of The Total Environment*, Vol. 755, 142543, doi: 10.1016/J.SCITOTENV.2020.142543.

Chontanawat, J. (2020), “Relationship between energy consumption, CO2 emission and economic growth in ASEAN: cointegration and causality model”, *Energy Reports*, Vol. 6, pp. 660-665, doi: 10.1016/j.egyr.2019.09.046.

Elliott, G., Rothenberg, T.J. and Stock, J.H. (1996), “Efficient tests for an autoregressive unit root”, *Econometrica*, Vol. 64 No. 4, p. 813, doi: 10.2307/2171846.

Engle, R.F. and Granger, C.W.J. (2015), “Co-integration and error correction: representation, estimation, and testing”, *Applied Econometrics*, Vol. 39 No. 3, pp. 107-135, doi: 10.2307/1913236.

Erdoğan, S., Yıldırım, D.Ç. and Gedikli, A. (2019), “International journal of energy economics and policy investigation of causality analysis between economic growth and CO 2 emissions: the case of BRICS-T countries”, *International Journal of Energy Economics and Policy*, Vol. 9, doi: 10.32479/ijeep.8546.

Esen, E. and Çelik Keçili, M. (2021), “Economic growth and health expenditure analysis for Turkey: evidence from time series”, *Journal of the Knowledge Economy*, pp. 1-15, doi: 10.1007/s13132-021-00789-8.

Esso, L.J. and Keho, Y. (2016), “Energy consumption, economic growth and carbon emissions: cointegration and causality evidence from selected African countries”, *Energy*, Vol. 114, pp. 492-497, doi: 10.1016/j.energy.2016.08.010.

Friedrich, J., Ge, M. and Pickens, A. (2020), *This Interactive Chart Shows Changes in the World's Top 10 Emitters*, World Resources Institute, available at: https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters

Fuller, R., Sandilya, K. and Hanrahan, D. (2019), "Pollution and health metrics: global, regional, and country analysis December 2019", available at: https://www.ehidc.org/resources/pollution-and-health-metrics-global-regional-and-country-analysis-december-2019 (accessed 24 August 2022).

Ganda, F. (2021), "The impact of health expenditure on environmental quality: the case of BRICS", *Development Studies Research*, Vol. 8 No. 1, pp. 199-217.

Ghorashi, N. and Rad, A.A. (2017), "Iran: application of dynamic simultaneous equation models", *RR Journal of Community Health Research*, Vol. 6 No. 2, p. 110.

Gorus, M.S. and Aydin, M. (2019), "The relationship between energy consumption, economic growth, and CO2 emission in MENA countries: causality analysis in the frequency domain", *Energy*, Vol. 168, pp. 815-822, doi: 10.1016/J.ENERGY.2018.11.139.

Grossman, M. (1999), "The human capital model of the demand for health", available at: https://ideas.repec.org/p/nbr/nberwo/7078.html

Grossman, G.M. and Krueger, A.B. (1995), "Economic growth and the environment", *Quarterly Journal of Economics*, Vol. 110 No. 2, pp. 353-377, doi: 10.2307/2118443.

Halıcı-Tülüce, N.S., Doğan, İ. and Dumrul, C. (2015), "Is income relevant for health expenditure and economic growth nexus?", *International Journal of Health Economics and Management*, Vol. 16 No. 1, pp. 23-49, 2015 16:1, doi: 10.1007/S10754-015-9179-8.

He, J. and Richard, P. (2010), "Environmental Kuznets curve for CO2 in Canada", *Ecological Economics*, Vol. 69 No. 5, pp. 1083-1093, doi: 10.1016/J.ECOLECON.2009.11.030.

Ibukun, C.O. (2021), "The role of governance in the health expenditure–health outcomes nexus: insights from West Africa", *International Journal of Social Economics*, Vol. 48 No. 4, pp. 557-570, doi: 10.1108/IJSE-06-2020-0404.

Ibukun, C.O. and Osinubi, T.T. (2020), "Environmental quality, economic growth, and health expenditure: empirical evidence from a panel of African countries", *African Journal of Economic Review*, Vol. VIII No. II, pp. 119-140.

International Energy Agency (IEA) (2016), "Small increase in energy investment could cut premature deaths from air pollution in half by 2040, says new IEA report", *News*, available at: https://www.iea.org/news/small-increase-in-energy-investment-could-cut-premature-deaths-from-air-pollution-in-half-by-2040-says-new-iea-report

IQAir (2020), "World air quality report", 2020 World Air Quality Report August, pp. 1-41, available at: https://www.iqair.com/world-most-polluted-cities/world-air-quality-report-2020-en.pdf

Johansen, S. (1988), "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, Vol. 12 Nos 2-3, pp. 231-254, doi: 10.1016/0165-1889(88)90041-3.

Johansen, S. and Juselius, K. (1990), "Maximum likelihood estimation and inference on cointegration — with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52 No. 2, pp. 169-210, doi: 10.1111/j.1468-0084.1990.mp52002003.x.

Mujtaba, G. and Shahzad, S.J.H. (2021), "Air pollutants, economic growth and public health: implications for sustainable development in OECD countries", *Environmental Science and Pollution Research*, Vol. 28 No. 10, pp. 12686-12698, doi: 10.1007/s11356-020-11212-1.

Murthy, V.N.R. and Okunade, A.A. (2016), "Determinants of U.S. health expenditure: evidence from autoregressive distributed lag (ARDL) approach to cointegration", *Economic Modelling*, Vol. 59, pp. 67-73, doi: 10.1016/J.ECONMOD.2016.07.001.

Myllyvirta, L. (2020), "Quantifying the economic costs of air pollution from fossil fuels key messages", Centre for Research on Energy and Celan Air, available at: https://energyandcleanair.org/wp/wp-content/uploads/2020/02/Cost-of-fossil-fuels-briefing.pdf

Nasreen, S. (2021), "Association between health expenditures, economic growth and environmental pollution: long-run and causality analysis from Asian economies", *The International Journal of Health Planning and Management*, Vol. 36 No. 3, pp. 925-944, doi: 10.1002/HPM.3132.

Odhiambo, N.M. (2009), "Electricity consumption and economic growth in South Africa : a trivariate causality test", *Energy Economics*, Vol. 31 No. 5, pp. 635-640, doi: 10.1016/j.eneco.2009.01.005.

Odugbesan, J.A. and Rjoub, H. (2020), "Relationship among economic growth, energy consumption, CO2 emission, and urbanization: evidence from MINT countries", *SAGE Open*, Vol. 10 No. 2, pp. 1-15, doi: 10.1177/2158244020914648.

OECD (2021), "Health resources - health spending - OECD data", in *OECD Data*, available at: https://data.oecd.org/healthres/health-spending.htm

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16 No. 3, pp. 289-326, doi: 10.1002/jae.616.

Phillips, P.C.B. and Perron, P. (1988), "Testing for a unit root in time series regression", *Biometrika*, Vol. 75 No. 2, pp. 335-346, doi: 10.1093/biomet/75.2.335.

Sileem, H.H.M. (2016), "Health expenditure, climate changes and corruption in the MENA region: a granger causality approach", *Journal of African Development*, Vol. 18 No. 2, pp. 61-72, available at: https://www.jstor.org/stable/10.5325/jafrideve.18.2.0061

Stefan, D., Gherghina, C. and Pasmangiu, G. (2019), "Exploring the causal nexus between energy consumption, environmental pollution and economic growth: empirical evidence from central and Eastern Europe", *Energies*, Vol. 12 No. 3704, pp. 1-27.

Stern, D.I. (2017), "The environmental Kuznets curve", *Oxford Research Encyclopedia of Environmental Science*. doi: 10.1093/ACREFORE/9780199389414.013.401.

Wang, C.-M., Hsueh, H.-P., Li, F. and Wu, C.-F. (2019), "Bootstrap ARDL on health expenditure, CO2 emissions, and GDP growth relationship for 18 OECD countries", *Frontiers in Public Health*, Vol. 7, p. 324, doi: 10.3389/FPUBH.2019.00324.

Wang, Z., Asghar, M.M., Zaidi, S.A.H. and Wang, B. (2019), "Dynamic linkages among CO 2 emissions, health expenditures, and economic growth: empirical evidence from Pakistan", *Environmental Science and Pollution Research*, Vol. 26 No. 15, pp. 15285-15299, 2019 26:15, doi: 10.1007/S11356-019-04876-X.

WDI (2021), "World development Indicators | DataBank", available at: https://databank.worldbank.org/reports.aspx?source=2&series=SH.XPD.GHED.GD.ZS&country=NGA#

Yahaya, A., Nor, N.M., Habibullah, S., Ghani, J.A. and Noor, Z.M. (2016), "How relevant is environmental quality to per capita health expenditures? Empirical evidence from panel of developing countries", *SpringerPlus*. doi: 10.1186/s40064-016-2505-x.

Yang, J. and Zhang, B. (2018), "Air pollution and healthcare expenditure: implication for the benefit of air pollution control in China", *Environment International*, Vol. 120, pp. 443-455, doi: 10.1016/J.ENVINT.2018.08.011.

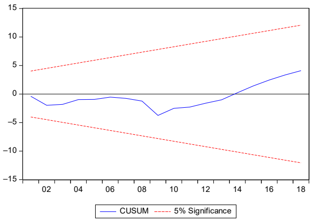
Yazdi, S.K. and Khanalizadeh, B. (2017), "Air pollution, economic growth and health care expenditure", *Economic Research-Ekonomska Istrazivanja*, Vol. 30 No. 1, pp. 1181-1190, doi: 10.1080/1331677X.2017.1314823.

Ye, L. and Zhang, X. (2018), "Nonlinear granger causality between health care expenditure and economic growth in the OECD and major developing countries", *International Journal of Environmental Research and Public Health*, Vol. 15 No. 9, p. 1953, 2018, Vol. 15, Page 1953, doi: 10.3390/IJERPH15091953.

Zaidi, S. and Saidi, K. (2018), "Environmental pollution, health expenditure and economic growth in the Sub-Saharan Africa countries: panel ARDL approach", *Sustainable Cities and Society*, Vol. 41, pp. 833-840, doi: 10.1016/j.scs.2018.04.034.

Appendix

Mexico



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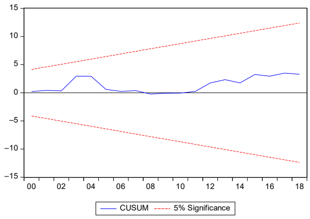

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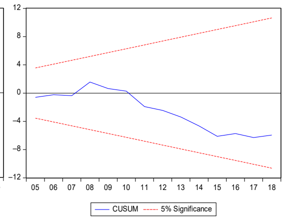

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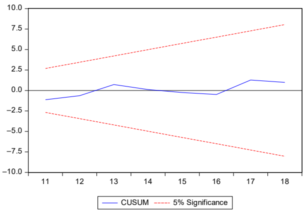

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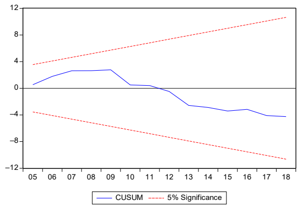

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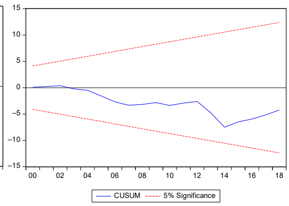

Model 3

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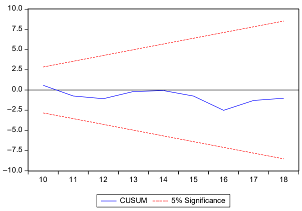

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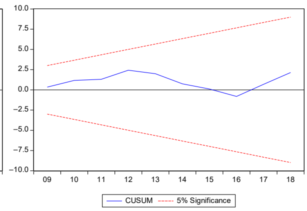

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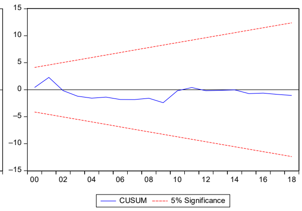

Model 3

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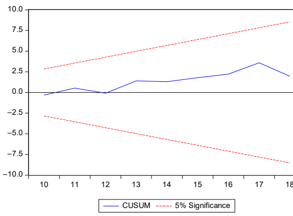

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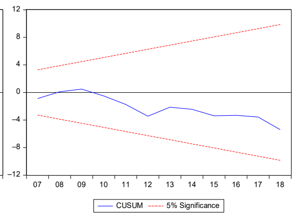

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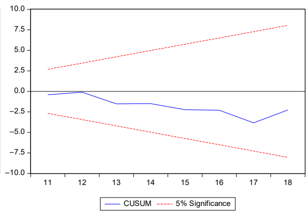

Model 3

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