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The Effects of Energy Consumption and National Output on CO₂ Emissions: New Evidence from OIC Countries Using a Panel ARDL Analysis

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Abstract: The issue of energy has been debated among policymakers and economists. Energy plays an important role in generating economic activities. On the other hand, it can have deleterious impacts on the environment as more carbon dioxide (CO₂) emissions will be released. Most previous studies focused on total energy rather than types of energy such as oil and gas in investigating the effects of energy consumption on CO₂ emissions. Therefore, this study investigates the effects of oil and gas consumption rather than total energy consumption on CO₂ emissions in 20 Organization of Islamic Cooperation (OIC) countries. The dynamic heterogeneous panel (panel autoregressive distributed lag model – panel ARDL) approach namely pooled mean group (PMG), mean group (MG), and dynamic fixed effect (DFE) were employed. The main results reveal that in the long run, overall national output contributes to higher environmental degradation. However, in the short run, overall national output does not affect CO₂ emissions. The results also suggest that the population can reduce CO₂ emissions in the short run but leaves no effect in the long run. Besides, gas consumption and oil consumption can have deleterious effects on the environment. The effect of oil consumption is greater than the effect of gas consumption on the environment. Therefore, it is important to consume more renewable energy such as solar, biodiesel, and hydro to replace non-renewable energy, particularly oil, in a bid to conserve the environment.

Keywords: CO₂ emissions; gas consumption; national output; oil consumption; panel ARDL

1. Introduction

Energy consumption has been argued to be a determinant of the economy. Hence, energy is as important as other factors for economic growth such as labor and capital. Several studies suggested that energy consumption plays an important role in determining economic growth [1–3]. Cassim et al. (2004) stated that energy is used for economic development as it generates economic activities [4]. Ozturk et al. (2010) found that in upper and lower-middle-income countries, energy consumption is the determinant of economic growth [5]. Thus, a rise in energy can expand the economy. Ighodaro (2010) used several types of energy sources such as oil and electricity as a proxy for energy and determined which energy will influence economic growth [6]. It was found that economic growth hinges on several sources of energy. Therefore, exhaustion or reduction of any type of energy can disrupt economic growth.

However, this issue remains a topic for debate as the use of energy can be detrimental to the environment. The environmental problem emerges when a country consumes more energy. This is
because the use of more energy can produce more CO\(_2\) emissions and thus affect air quality. According to a report released by the Malaysian Department of Environment (2010), CO\(_2\) emissions contribute the largest share of the greenhouse effects and subsequently, cause global warming [7]. Humans can be exposed to many risks such as cancers and mental illness. Climate change can also threaten the economy. Agriculture and tourism will be affected by climate change. In addition, Jalil and Mahmud (2009) acknowledged that environmental sustainability cannot be attained as excessive energy is used [8]. Therefore, energy consumption should be reduced to conserve the environment.

Due to environmental issues, several protocols such as the Kyoto Protocol and Montreal Protocol have been signed by numerous countries all over the world. The Kyoto Protocol was established in 1997 in response to global warming stemming from greenhouse gasses. Countries that agree to implement the Kyoto Protocol are committed to reducing greenhouse gasses including CO\(_2\). The Montreal Protocol was signed in 1987 in response to ozone depletion. These protocols aim to reduce environmental pollution and thus energy consumption should be reduced. Belke et al. (2011) stated that policies to reduce energy are complex if they can affect economic growth [9]. Ighodaro and Ovenseri-Ogbomo (2008) stated that energy conservation policies can be formulated if energy consumption does not affect the economy [10]. Previous studies have also mentioned the importance of energy in the economy [11–14]. Nevertheless, its consumption can create environmental problems as it can produce CO\(_2\) emissions. Therefore, a policy to reduce energy consumption, as well as CO\(_2\) emissions, should be formulated with much attention on both economic development and the environment. Wei et al. (2009) found that coal and other low-quality energy consumption should be limited to preserve the environment as their consumption can have deleterious effects on the environment [15]. Therefore, the consumption of energy should be reduced to conserve the environment. However, this reduction can pose damaging effects on economic growth.

A large number of previous studies have been conducted to investigate the effects of energy consumption and economic growth on CO\(_2\) emissions, however they used total energy consumption as a proxy for energy consumption and studies on the types of energy are still sparse. A limited number of studies split into two types of energy: renewable and non-renewable energy. Therefore, this current study employs a panel data analysis and attempts to discover the effects of several types of energy (oil and gas) on CO\(_2\) emissions in 20 OIC countries. This can shed light on a bigger scope of the investigation into the effects of oil and gas consumption on CO\(_2\) emissions.

More than 100 countries have adopted the Kyoto and Montreal protocols including numerous Organization of Islamic Cooperation (OIC) countries. However, environmental issues still emerge in the countries despite the fact that the nations are moving towards conserving the environment. Vaghefi et al. (2015) stated that Islamic countries find it difficult to implement the green economy due to several factors such as higher poverty, a lot of conflicts, and a high dependency on natural resources [16]. Hence, CO\(_2\) emissions in those countries spiral out of control. Total CO\(_2\) emissions produced by OIC countries exhibit an upward trend. According to the Union of Concerned Scientists (2019), Iran was ranked 1st among OIC countries that emitted most CO\(_2\) emissions in 2016 with its emissions at 863.4 MT, followed by Saudi Arabia (527.2 MT) [17]. They were ranked in the top 10 in the world. This shows that OIC countries are less concerned with environmental degradation rather than economic growth.

2. Literature Review

National output and environmental quality have become a current topic for policymakers to debate. Some have argued that national output will lead to environmental degradation while others have said that environmental problems can be mitigated by having a higher national output. Numerous researchers were interested in studying the relationships among energy consumption, national output, and CO\(_2\) emissions [18–22].

Azomahou et al. (2006) investigated the relationship between national output and environmental degradation based on the environmental Kuznets curve (EKC) in 100 countries using data from 1960 to
The results showed that GDP per capita can influence CO$_2$ emission. The findings were supported by Stolyarova (2009) who also examined the relationship between CO$_2$ emissions and national output in 93 countries for the period 1960–2008 [24]. The results showed that national output can have a deleterious effect on the environment. Meanwhile, Apergis and Payne (2010) examined the relationship between energy consumption, national output, and CO$_2$ emissions using data in 11 Commonwealth of Independent States (CIS) countries from 1992 to 2004 [25]. The results showed that most of the countries rely on several energy sources such as oil, coal, and natural gas.

An investigation into the association between national output and environmental degradation has also been conducted in more than 100 countries by Maddison and Rehdanz (2008) using data from 1990 to 2005 [26]. The results showed that the significant relationship between national output and environmental problems are dependent on the sub-group of countries. In several countries, such as Asian countries, no relationship was found between national output and environmental degradation.

Besides, Farhani and Rejeb (2012) examined the linkage among energy consumption, national output, and environmental degradation in 15 Middle East and North Africa (MENA) countries, using data from 1973 to 2008 [27]. The results showed that there is a relationship between energy consumption, national output, and environmental degradation. Energy consumption can affect national output and environmental degradation without any feedback for both of the variables in the short run. Higher economic growth can lead to higher environmental degradation and this can increase health expenditure in the MENA countries. This has been evidenced by Yazdi and Khanalizadeh (2017) using panel ARDL [28].

Dritsaki and Dritsaki (2014) investigated the causal relationship between energy consumption, national output, and CO$_2$ emissions in Southern Europe for the period 1960–2009 [29]. The results from fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) tests showed that an increase in energy consumption can result in a rise in CO$_2$ emissions in the countries. For the individual ordinary least square (OLS) and DOLS tests, the results confirmed the existence of a strong positive relationship between energy consumption and national output in Greece and Spain. Al-mulali et al. (2012) also employed the same method (FMOLS and DOLS) [30]. However, the study investigated in different regions: East Asia and Pacific, East Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, Sub-Saharan Africa, and Western Europe. The study added urbanization to their model and the results revealed that urbanization and energy consumption can affect CO$_2$ emissions positively in most of the countries. The rest of the countries showed mixed results. The results from low-income countries suggested that there is no effect of urbanization and energy consumption on CO$_2$ emissions. Islam et al. (2017) also explored the relationship between energy consumption, national output, and CO$_2$ emissions in selected Southeast Asian countries: Malaysia, Indonesia, and Thailand [31]. Their discussion is wider as population, poverty, and forest area were also included. Panel co-integration and panel Granger causality are employed in analyzing data from 1991 to 2010. The results show that energy consumption and economic growth can increase CO$_2$ emissions while the population has a small effect on CO$_2$ emissions. On the other hand, poverty and forest area were found to affect CO$_2$ emissions negatively.

Menyah and Wolde-Rufael (2010), as well as Alkhathlan et al. (2012), employed the ARDL approach in their studies in the United States and Saudi Arabia, respectively. Menyah and Wolde-Rufael (2010) examined the relationship between renewable and nuclear energy consumption, CO$_2$ emissions, and national output using the data from 1960 to 2007 [32]. Conducting the modified version of the Granger causality test, the results showed that there is a unidirectional relationship moving from nuclear energy consumption to environmental degradation and there is no relationship moving from renewable energy consumption to environmental degradation. Apart from that, it was also found that nuclear energy consumption can reduce environmental degradation.

Alkhathlan et al. (2012) investigated the short-run and long-run relationships among CO$_2$ emissions, energy consumption, and national output in Saudi Arabia over the period 1980–2008 [33].
approaches, the empirical results showed that there is an existence of a long-run relationship between energy consumption and national output. The results of the Granger causality test also showed that national output does not Granger-cause CO\textsubscript{2} emission. In light of this result, as well as the fact that Saudi Arabia is the largest oil exporter and producer in the world and, at the same time, the 14th largest producer of CO\textsubscript{2} emissions in the world, policies on energy consumption were proposed for the Saudi Arabia case.

Most previous studies focused on energy consumption rather than types of energy such as oil and gas. However, little previous literature focused on several types of energy as a proxy for energy. For example, Khan et al. (2019) investigated the impact of oil, coal, and natural gas consumption on CO\textsubscript{2} emissions in Pakistan in the short run and long run [34]. Amri (2017) divided into two types of energy, namely renewable energy and non-renewable energy, and the study also supported that non-renewable energy consumption can be harmful to the environment [35]. A lack of previous studies addressing the issue of energy types on CO\textsubscript{2} emissions in OIC countries has motivated these researchers to embark on this investigation.

3. Research Methodology

A vast array of previous literature adopted the Impact, Population, Affluence, and Technology (IPAT) model in their studies to examine the effect of energy consumption on CO\textsubscript{2} emissions [36]. The model is very easy to understand the factors affecting the environment. Therefore, this study also applies the IPAT model to explore the effects of national output and energy consumption on CO\textsubscript{2} emissions. IPAT is an acronym for the impact on the environment (I), population (P), affluence (A), and technology (T). The basic model is written as follows:

$$I = f(P, A, T).$$ (1)

This study uses CO\textsubscript{2} emissions as a proxy for the impact on environmental degradation (since it constitutes the largest share of environmental degradation), energy consumption as a proxy for technology [37], and gross domestic product (GDP) per capita as a proxy for affluence. The model in Equation (1) can be expanded to be Equation (2). A panel data analysis is employed in this study. The data are extracted from the International Energy Agency and the World Bank. Several tests are conducted, such as a panel unit root, panel co-integration, and dynamic heterogeneous panel estimations, namely pooled mean group (PMG), mean group (MG), and dynamic fixed-effect (DFE). The model specification is as follows:

$$\ln CO_{2it} = \beta_0 + \beta_1 \ln GDPP_{it} + \beta_2 \ln E_{it} + \beta_3 \ln P_{it} + v_{it}. \quad (2)$$

where CO\textsubscript{2} represents CO\textsubscript{2} emissions, GDPP represents gross domestic product per capita (national output), E represents energy consumptions, and P is the population. All variables are transformed into a log form. The baseline model in the equation has been used by Begum et al. (2015), and Yeh and Liao (2017) [38,39].

From Equation (2), energy consumption (E) will be divided into 2 types, namely the natural gas (G) and oil consumption (O), and the equation is as follows:

$$\ln CO_{2it} = \beta_0 + \beta_1 \ln GDPP_{it} + \beta_2 \ln O_{it} + \beta_3 \ln G_{it} + \beta_4 \ln P_{it} + v_{it}. \quad (3)$$

3.1. Panel Unit Root Tests

The panel unit root tests are performed for all selected variables. The test is conducted to ensure that there is no tendency for spurious regression when using panel data. The main reason that the panel unit root test performed is to solve the low power problem when Augmented Dickey-Fuller (ADF) is applied. Campbell and Perron (1991) and Ramirez (2007) stated that the reliability of the estimation can be questioned as the unit root test has low power when the number of observations
used in time series studies is less than 50 [40,41]. The use of the panel unit root test can overcome this problem as it has more power and standard asymptotic distribution. Therefore, reliable evidence can be provided by the test. Moreover, as stated by Levin, Lin and Chu (2002), Breitung (2000) and Im, Pesaran, and Shin (1997) the panel unit root test is more efficient compared to the time series unit root test [42–44]. These methods have been widely used in previous studies on energy consumption [45].

3.2. Panel Estimation

The PMG estimator can have short-run estimation including the intercept, the speed of adjustment, and error variance to be heterogeneous. The long-run slope coefficient is limited to be homogenous. The advantage of using this method is that it is more efficient and consistent to capture the existence of a long-run relationship. Nevertheless, it needs the coefficient of error correction term to be lower than 2 and negative. Besides, the critical assumption that the consistency of estimation is needed and thus it can cause no serial correlation in the residual of error correction model, resulting in exogeneity in the explanatory variables. The conditions can be fulfilled once the lags (p, q) are incorporated for both the dependent (p) and independent (q) variables. This method needs large sizes of T and N, and T must be larger than N. According to Pesaran et al. (1999), the number of N is approximately 20–30 countries [46]. The second estimator is MG and this estimator was introduced by Pesaran and Smith (1995) [47]. The advantage of using this estimator is that it allows separate regressions for each country and the coefficients. It is slightly different from PMG as it is not limited to the procedures for estimators. It can produce different and heterogenous coefficients for every single country in the long run and short run. The third estimator is a dynamic fixed effect (DFE). This estimator is similar to the PMG estimator. It limits the vector co-integration coefficient to be the same among all long-run panels. Other than that, it limits the speed of adjustment and thus makes the short-run coefficient the same and the specific panel coefficient is allowed.

MG long-run relationship models are written as follows:

\[
\ln CO_{2it} = \theta_i + \delta_{0i}\ln CO_{2i,t-1} + \delta_1\ln O_{it} + \delta_2\ln G_{it} + \delta_3\ln P_{it} + \delta_4\ln GDPP_{it} + \varepsilon_{it}. \quad (4)
\]

Whereas, PMG and DFE long-run relationship models are written as follows:

\[
\ln CO_{2it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij}\ln CO_{2i,t-j} + \sum_{j=1}^{q} \delta_{ij}\ln G_{it-j} + \sum_{j=1}^{q} \delta_{ij}\ln O_{it-j} + \sum_{j=1}^{q} \delta_{ij}\ln P_{it-j} + \varepsilon_{it}. \quad (5)
\]

Where, \(i\) represents countries (1, 2, 3... 20), \(t\) is the year (1990–2017), \(j\) is the optimum time lag, and \(\mu_i\) is a fixed effect.

The short-run relationship with error correction models is written as follows:

\[
\Delta \ln CO_{2it} = \mu_i + \phi_1(\ln CO_{2i,t-1} - \lambda_1\ln G_{it} - \lambda_2\ln O_{it} - \lambda_3\ln P_{it} - \lambda_4\ln GDPP_{it}) + \sum_{j=1}^{p} \lambda_{ij}\ln CO_{2i,t-j} + \sum_{j=1}^{q} \delta_{ij}\ln G_{it-j} + \sum_{j=1}^{q} \delta_{ij}\ln O_{it-j} + \sum_{j=1}^{q} \delta_{ij}\ln P_{it-j} + \varepsilon_{it}. \quad (6)
\]
3.3. Hausman Test

The Hausman test is important to choose either PMG or MG and PMG or DFE. Between PMG and MG, if the null hypothesis is accepted, the PMG is favored over MG as it is more efficient. If the null hypothesis is rejected, then MG is selected over PMG. Between PMG and DFE, if the null hypothesis is accepted, then PMG is better than DFE and if the null hypothesis is rejected, then DFE is better than PMG.

4. Empirical Findings and Discussions

This study employs the PMG, MG, and DFE estimators to investigate the effects of energy consumption and national output on CO₂ emissions in 20 OIC countries (Algeria, Bahrain, Bangladesh, Egypt, Gabon, Indonesia, Iran, Malaysia, Nigeria, Pakistan, Saudi Arabia, Tajikistan, Tunisia, Turkey, United Arab Emirates (UAE), Azerbaijan, Kyrgyzstan, Morocco, Oman, and Uzbekistan). Unit root tests based on Levin, Lin, and Chu (LLC), and Im, Pesaran, and Shin (IPS) are performed to see the existence of stationarity of the data for all the variables (lnGDPP, lnCO₂, lnG, and lnO). Therefore, it is essential to determine the order of integration for all the variables used in this study. Table 1 shows the results of the two tests and it can be learned that lnCO₂ is stationary at a level for LLC and the other variables (lnGDPP, lnCO₂, lnG, and lnO) are not stationary at a level for LLC and IPS. However, all the variables are stationary at first difference for both LLC and IPS. This shows that the variables are mixed order of integration (I(1) and I(0)). Based on these findings, the panel ARDL can be applied.

|              | Levin, Lin, and Chu (LLC) | IM, Pesaran, and Shin (IPS) |
|--------------|---------------------------|-----------------------------|
| Level        | First Difference          | Level                       | First Difference          |
| lnGDPP       | 1.4466                    | 3.9347                      | −7.1175 ***               |
| (0.9260)     | (0.0000)                  | (0.9260)                    | (0.0000)                  |
| lnP          | 8.41396                   | −13.3866 ***                | 13.9662                   |
| (1.0000)     | (0.0000)                  | (1.0000)                    | (0.0000)                  |
| lnCO₂        | −4.6125 ***               | −7.2991 ***                 | −1.6794 **                |
| (0.0000)     | (0.0000)                  | (0.0465)                    | (0.0000)                  |
| lnG          | −3.29984                  | −10.1227 ***                | 1.07324                   |
| (0.0005)     | (0.0000)                  | (0.8584)                    | (0.0000)                  |
| lnO          | −1.0629                   | −5.5977 ***                 | 2.4410                    |
| (0.1439)     | (0.0000)                  | (0.9927)                    | (0.0000)                  |

Note: *** and ** indicate the significance levels of 1% and 5%, respectively.

In order to estimate the effects of energy consumption and output on CO₂ emission, this study employs PMG, MG, and DFE estimators. The Hausman test is important to select either PMG or MG and PMG or DFE. The results of the Hausman test between PMG and MG show that the null hypothesis is accepted and therefore, PMG is favored over MG. The results of the Hausman test between PMG and DFE indicate that the null hypothesis is also accepted, suggesting that PMG is chosen over DFE. Table 2 shows the results of PMG, MG, and DFE estimators with the Hausman tests. The results indicate that national output can affect CO₂ emissions in the long run. The relationship is positive and this suggests that any increase in economic growth, environmental degradation can increase in the long run. These results are consistent with the results of DFE. However, the results of MG do not suggest that there is any significant effect of national output on CO₂ emissions in the long run. The results of MG and DFE show that the population does not significantly affect CO₂ emissions in the long run. However, the results of PMG show that the population can affect CO₂ emissions. Based on the results of PMG and MG, both consistently show that gas consumption can significantly contribute to higher CO₂ emissions in the long run. The results of DFE, on the other hand, show that gas consumption does significantly and negatively affect CO₂ emissions in the long run. The results of all estimators (PMG,
MG, and DFE) consistently show that oil consumption does affect CO₂ emissions in a positive manner in the long run.

**Table 2. Long-run estimation results.**

| Variable | PMG Coefficient | PMG Prob. | MG Coefficient | MG Prob. | DFE Coefficient | DFE Prob. |
|----------|-----------------|-----------|----------------|----------|-----------------|-----------|
| lnGDPP   | 0.2148 ***      | 0.000     | 0.0190         | 0.940    | 0.3678 **       | 0.016     |
| lnP      | 0.3050 ***      | 0.000     | 0.2694         | 0.451    | 0.7347          | 0.002     |
| lnG      | 0.1723 ***      | 0.000     | 0.1490 ***     | 0.006    | −0.1543 *       | 0.068     |
| lnO      | 0.3206 ***      | 0.000     | 0.6399 **      | 0.011    | 0.4607 ***      | 0.001     |

Hausman 0.94 0.919 0.24 0.993

Note: ***, ** and * indicate the significance levels of 1%, 5%, and 10%, respectively.

The PMG, MG, and DFE estimators allow us to see the short-run effects. Table 3 shows the results of those estimators. The values of error correct term (ECT) are negative and significant in all three estimators and thus they confirm the existence of long-run relationships. The results reveal that national output does not significantly influence CO₂ emissions in the short run. These consistent results obtained from only two estimators (PMG and MG), while DFE proves that national output can significantly contribute to higher CO₂ emissions. The results of PMG and DFE reveal that population plays an important role in reducing CO₂ emissions in the short run. However, the results of MG show no significant effect on the population on CO₂ emissions. Gas consumption is found to affect CO₂ emissions in a positive manner. These results are obtained from PMG and DFE but not MG. Two estimators (PMG and DFE) consistently show that oil consumption can significantly increase CO₂ emissions in the short run. However, the results of MG show that there is no significant effect of oil consumption on CO₂ emissions.

**Table 3. Short-run estimation results.**

| Variable | PMG Coefficient | PMG Prob. | MG Coefficient | MG Prob. | DFE Coefficient | DFE Prob. |
|----------|-----------------|-----------|----------------|----------|-----------------|-----------|
| ECT      | −0.2662 ***     | 0.000     | −0.6762 ***    | 0.000    | −0.0711 ***     | 0.000     |
| lnGDPP   | 0.0438          | 0.581     | −0.0512        | 0.621    | 0.2282 ***      | 0.000     |
| lnP      | −5.7218 **      | 0.044     | −13.2406       | 0.167    | 0.4020 *        | 0.050     |
| lnG      | 0.1055 ***      | 0.000     | 0.0376         | 0.188    | 0.1014 ***      | 0.000     |
| lnO      | 0.1772 ***      | 0.000     | 0.0582         | 0.131    | 0.2570 ***      | 0.000     |
| C        | −0.2242 **      | 0.015     | −4.1874        | 0.205    | −0.5419 **      | 0.026     |

Hausman 0.98 0.913 0.24 0.993

Note: *** and ** indicate the significance levels of 1% and 5%, respectively.

The PMG estimator is selected over the other estimator based on the results of the Hausman test. PMG can capture the short-run effects of national output and energy consumption on CO₂ emissions in every single country. The results are reported in Table 4. From the table, it can be learned that national output does significantly increase CO₂ emissions in the short run in Algeria, Tajikistan, and Malaysia. However, in Nigeria and Turkey, the national output can significantly reduce CO₂ emissions in the short run. In other countries, the national output does not significantly influence CO₂ emissions. Table 4 also shows that the population can reduce CO₂ emissions in Bangladesh, Gabon, Iran, Turkey, and Uzbekistan. In Kyrgyzstan and Algeria, on the other hand, the population can significantly increase CO₂ emissions. In the rest of the countries, the population does not significantly affect CO₂ emissions. Gas consumption can significantly increase CO₂ emissions in Algeria, Egypt, Iran, Nigeria, Pakistan, Saudi Arabia, Tajikistan, UAE, Azerbaijan, Kyrgyzstan, Oman, and Uzbekistan. However, gas consumption is found to have no significant effect on CO₂ emissions in other OIC countries (Algeria,
Bahrain, Bangladesh, Gabon, Indonesia, Malaysia, Tunisia, Turkey, and Morocco). Oil consumption can significantly affect CO₂ emissions in most of the OIC countries: Bangladesh, Egypt, Iran, Nigeria, Pakistan, Saudi Arabia, Tajikistan, Tunisia, Algeria, Azerbaijan, Morocco, and Oman. In other countries (Algeria, Bahrain, Gabon, Indonesia, Malaysia, Turkey, Kyrgyzstan, UAE, and Uzbekistan) oil consumption does not significantly affect CO₂ emissions in the short run.

Table 4. Short-run country specific results on 20 OIC countries.

| Country        | lnGDPP  | lnP      | lnG       | lnO      | C        |
|----------------|---------|----------|-----------|----------|----------|
| Algeria        | 0.6230*** | 5.8872*** | 0.1118*   | 0.0315   | -0.6664** |
| Bahrain        | -0.2743 | -0.6789  | 0.0722    | 0.0023   | -0.9964  |
| Bangladesh     | 0.2334   | -19.3243** | -0.0055   | 0.1913** | -0.2814  |
| Egypt          | -0.5900  | -4.1921   | 0.0663*** | 0.6001*** | 0.0662   |
| Gabon          | 0.0484   | -14.7825*** | 0.0333   | 0.0104   | -0.1319  |
| Indonesia      | 0.0711   | -22.8923** | -0.0645   | 0.0053   | -0.7158** |
| Iran           | 0.1052   | -3.4522*  | 0.3112*** | 0.2265*** | 0.0130   |
| Malaysia       | 0.5932*** | 0.2475   | -0.0084   | -0.1033  | -0.1565  |
| Nigeria        | -0.5637* | -41.3628  | 0.0591*   | 0.3157*** | 0.8601   |
| Pakistan       | 0.5382   | -0.2956   | 0.3952*** | 0.2957*** | -0.1415  |
| Saudi Arabia   | -0.0649  | 0.9272    | 0.0831*** | 0.3705*** | 0.0106   |
| Tajikistan     | 0.5357** | 10.5095   | 0.0950*** | 0.3628*** | -0.1592  |
| Tunisia        | 0.1254   | 0.5914    | 0.0770    | 0.2461*** | -0.3634  |
| Turkey         | -0.3276** | -24.3013*** | -0.0064   | 0.0017   | -0.6489  |
| UAE            | 0.2968   | 0.3855*   | 0.2456*** | 0.2230   | -0.0522  |
| Azerbaijan     | 0.0869   | -4.5452   | 0.2355*** | 0.1436** | -0.0250  |
| Kyrgyzstan     | -0.1454  | 8.6789*   | 0.0764*   | 0.1067   | -0.7900** |
| Morocco        | -0.1074  | -1.2649   | 0.0064    | 0.3532*** | -0.0614  |
| Oman           | -0.1889  | 0.0964    | 0.0446*   | 0.2131*** | -0.0532  |
| Uzbekistan     | -0.1182  | -4.4738** | 0.2813*** | -0.0518  | -1.0948  |

Note: ***, ** and * indicate the significance levels of 1%, 5%, and 10%, respectively.

A variance inflation factor (VIF) test is important to see whether there is any correlation among independent variables or multicollinearity. This is to ensure that there is no spurious regression that might lead to bias inferences. This study used a linear regression analysis before testing the variance inflation factor (VIF) and the results are reported in Table 5. The table shows that there is no multicollinearity. According to the rule of thumb, if VIF is less than 10, it suggests that there is no multicollinearity. In other words, lnP, lnG, lnGDPP, lnO are not correlated with each other.

Table 5. Regression analysis.

| Coefficient | Prob. | VIF |
|-------------|-------|-----|
| lnGDPP      | 0.0929* | 0.000 | 2.99 |
| lnP         | -0.0596* | 0.000 | 2.04 |
| lnG         | 0.1553* | 0.000 | 1.89 |
| lnO         | 0.6422* | 0.000 | 1.23 |
| C           | 3.5831* | 0.000 |     |

Note: * indicates the significance level of 1%.

5. Summary and Conclusions

This focal point of this study is to examine the effects of energy (oil and gas) consumption and national output on CO₂ emissions in 20 OIC countries (Algeria, Bahrain, Bangladesh, Egypt, Gabon, Indonesia, Iran, Malaysia, Nigeria, Pakistan, Saudi Arabia, Tajikistan, Tunisia, Turkey, UAE, Azerbaijan, Kyrgyzstan, Morocco, Oman, and Uzbekistan) from 1990 to 2017. The panel ARDL was employed and the results show that in the long run, overall national output can contribute to higher environmental degradation. These findings were supported by Asici (2011) [18]. However, in the short run, overall
national output does not affect CO₂ emissions. The results also suggest that the overall population can reduce CO₂ emissions in the short run but leaves no effect in the long run. Besides, gas consumption and oil consumption can have deleterious effects on the environment. The effect of oil consumption is greater than the effect of gas consumption on the environment.

Specifically, the national output can be harmful to the environment in Algeria (North Africa), Tajikistan (Central Asia), and Malaysia (East Asia) but it can reduce environmental degradation in Turkey (Western Asia) and Nigeria (West Africa). From the perspective of economies by Gross National Income (GNI) per capita, the national output can affect the environment in three upper-middle-income countries (Algeria, Malaysia, and Turkey), a lower-middle-income country (Nigeria), and a low-income country (Tajikistan). As for gas consumption, any increase in it can be harmful to the environment in many Central Asian countries (Algeria, Tajikistan, Azerbaijan, Kyrgyzstan, Uzbekistan), several Western Asian countries (Saudi Arabia, UAE, and Oman), a few South Asian countries (Iran and Pakistan), one North African country (namely Egypt), and a West Asian country (Nigeria). From the perspective of economies by GNI per capita, gas consumption can affect the environment in high-income countries (Saudi Arabia, UAE, and Oman), upper-income countries (Algeria, Azerbaijan, and Iran), lower-middle-income countries (Kyrgyzstan, Uzbekistan, Pakistan, Nigeria, and Egypt), and a low-income country (Tajikistan). Oil consumption can be harmful to the environment only in three South Asian countries (Bangladesh, Iran, and Pakistan), three North African countries (Egypt, Tunisia, and Morocco), two Western Asian countries (Saudi Arabia and Oman), two Central Asian countries (Tajikistan and Azerbaijan), and a West African country (Nigeria). From the perspective of economies by GNI per capita, oil consumption can affect the environment in high-income countries (Saudi Arabia and Oman), upper-middle-income countries (Azerbaijan), lower-middle-income countries (Azerbaijan), lower-middle-income countries (Bangladesh, Iran, Pakistan, Egypt, Tunisia, and Morocco), and a low-income country (Tajikistan).

Since the main findings show that overall energy consumption and national output can contribute to the environment, therefore, it can shed some light on the issue to ensure that policies can be formulated. An energy diversification policy can be implemented or improved. Renewable energy such as hydro, biofuel, and biomass can be increased and replaced non-renewable energy (oil and gas) in all OIC countries such as Egypt, Iran, Nigeria, etc. This is because the use of non-renewable energy can have detrimental effects on the environment. Abdullah (2018) stated that support from the government is important to ensure that renewable energy can substitute non-renewable energy [48]. It is also important for Algeria, Tajikistan, and Malaysia to use renewable energy in generating economic activities. This is because the increasing national output can be detrimental to the environment in those countries. Therefore, energy diversification policy to use more renewable energy can reduce environmental degradation without affecting economic activities. Other than that, carbon capture and storage technology can also be applied to all OIC countries. This technology can reduce CO₂ released from the use of fossil fuels in electricity generation and industrial processes to the air by 90%. This has been used by several countries such as the US, Canada, etc. Therefore, OIC countries can develop their economies without harming the environment. Imposing and improving carbon taxes can also reduce CO₂ emissions and this policy can lead firms to use green technologies in their production process. Otherwise, they have to pay for any excessive emission of CO₂ produced.

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