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Electricity Consumption and Economic Growth in D8 Countries: Bootstrap Panel Causality

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ABSTRACT

This study aims to test whether there is any relationship between the electricity consumption and gross domestic product of D8 countries (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey) and in the period of 1971 and 2014. The relationships between variables are examined through the Bootstrap Panel Causality test. The most important reason for choosing this test is that it reveals individual causality relationships for each country and that there is no need for unit root and/or cointegration testing prior to it. According to the Bootstrap Panel Causality test results, there is a positive and unidirectional causality relationship from electricity consumption to economic growth (the growth hypothesis) in Iran and from economic growth to electricity consumption in Indonesia and Nigeria (the conservation hypothesis). For Egypt and Malaysia, a positive and bidirectional causality relationship (the feedback hypothesis) is determined between the variables, while no causality (the neutrality hypothesis) relationship is found between the variables in Bangladesh, Pakistan, and Turkey.

ملخص

تهدف هذه الدراسة إلى اختبار ما إذا كانت هناك أي علاقة بين استهلاك الكهرباء والناتج المحلي الإجمالي للدول الثماني الإسلامية النامية D8 (إندونيسيا وإيران وباكستان وبنغلاديش وتركيا وماليزيا ومصر ونيجيريا) وفي الفترة ما بين 1971 و 2014. ويتم فحص العلاقات بين المتغيرات من خلال اختبار السببية التمهيدي.ويتمثل أهم سبب لاختيار هذا الاختبار في كونه يكشف عن علاقات سببية فردية لكل بلد وعدم الحاجة إلى إجراء اختبار جذر الوحدة و/أو الاندماج المشترك قبله. وطبقا لنتائج اختبار

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السببية التمهيدي، فهناك علاقة سببية إيجابية أحادية الاتجاه من استهلاك الكهرباء إلى النمو الاقتصادي (فرضية النمو) في إيران ومن النمو الاقتصادي إلى استهلاك الكهرباء في إندونيسيا ونيجيريا (فرضية الحفاظ على الطاقة). وبالنسبة لمصر وماليزيا، فإن العلاقة السببية الإيجابية ذات الاتجاه الثنائي (فرضية التغذية المرتدة) تتحدد بين المتغيرات، في حين لا توجد علاقة سببية (فرضية الحياد) بين المتغيرات في كل من بنغلاديش وباكستان وتركيا.

ABSTRAITE

Cette étude a pour but de tester s'il existe une relation entre la consommation d'électricité et le produit intérieur brut des pays du D8 (Bangladesh, Egypte, Indonésie, Iran, Malaisie, Nigéria, Pakistan, et Turquie) et dans la période de 1971 à 2014. Les relations entre les variables sont examinées par le test de causalité Bootstrap Panel. La raison la plus importante du choix de ce test est qu'il révèle des relations de causalité individuelles pour chaque pays et qu'il n'est pas nécessaire d'effectuer au préalable des tests de racine unitaire et/ou de cointégration. Selon les résultats du test de causalité Bootstrap Panel, il existe une relation de causalité positive et unidirectionnelle entre la consommation d'électricité et la croissance économique (hypothèse de croissance) en Iran et entre la croissance économique et la consommation d'électricité en Indonésie et au Nigeria (hypothèse de conservation). Pour l'Égypte et la Malaisie, une relation de causalité positive et bidirectionnelle (l'hypothèse de rétroaction) est déterminée entre les variables, tandis qu'aucune relation de causalité (l'hypothèse de neutralité) n'est trouvée entre les variables au Bangladesh, au Pakistan et en Turquie.

Keywords: Economic Growth, Electricity Consumption, Bootstrap Panel Causality, D8 Countries

JEL Classification: O10, Q40, C33

1. Introduction

Since the Industrial Revolution in which economics emerged as a branch of science, it is unlikely that industrialization, production, and economic growth can function without consuming energy. Energy, which accelerated the Industrial Revolution, was an important input for economic growth and a vital factor of production for economic growth (Ebohon, 1996).

The stagflation phenomenon experienced throughout the world with the oil crisis of 1973 once again demonstrated the importance of energy and its effects on economic growth. Restricting oil production by Middle Eastern oil-producing countries during this oil crisis has raised prices fourfold in a short time and left deep scars on the economies of industrialized countries. Especially with this crisis, there has been a significant increase in the number of studies examining the relations between energy consumption and economic growth. The basic need for energy for economic growth stems from the need for this input at almost every stage of the production process.

In the production processes, besides energy sources such as natural gas, oil, nuclear energy, and renewable energy, electricity has a special place in terms of being more widely used. The findings of studies investigating the relationships between electricity consumption and economic growth reveal four different results. These results are classified as the conservation, growth, feedback, and neutrality hypothesis. The conservation hypothesis is the existence of a causality relationship from economic growth to energy consumption. This hypothesis is based on the view that policies to prevent energy consumption and waste will not have negative effects on economic growth. In other words, reducing energy consumption does not prevent economic growth. The conservation hypothesis is supported if real output increases in the economy lead to an increase in energy consumption. Economic growth may slow due to political instability or a lack of good management of resources and reduced demand for goods and services, including energy consumption. In such a case, energy consumption is also negatively affected. Accordingly, policies aimed at reducing energy consumption or losses will have limited or no impact on economic growth. Such economies are economies with little energy dependence. The growth hypothesis is a finding of causality relationship from energy consumption to economic growth. In this hypothesis, energy consumption affects economic growth as a complement to labour and capital in the production process. According to this hypothesis, while electricity consumption has a positive effect on economic growth, decreases in electricity consumption have a negative effect on economic growth. The feedback hypothesis, which is another hypothesis in the literature, reveals the findings that there is a bidirectional causality relationship between the variables. In this hypothesis, energy consumption and real output interact with each other, but also have the characteristics of completing each other. In such a case, policies aimed at increasing efficiency in energy consumption do not have negative effects on economic growth. Lastly, the neutrality hypothesis indicates that there is no causality relationship between the variables. This hypothesis is based on the argument that electricity consumption is not a very important input for total output. The neutrality hypothesis does not have a positive or negative effect on the real output of energy-saving policies (Squalli, 2007: 1193; Payne, 2010: 723).

In this study, the relationship between the gross domestic product and electricity consumption of D8 countries (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey) between 1971 and 2014 is investigated by the Kónya (2006) bootstrap panel causality test. The D8 organization formed within the framework of economic and commercial cooperation of 8 developing Muslim countries was brought to the agenda during a seminar called "Cooperation in Development" held in Istanbul in 1996. D8 was officially established by a declaration signed in Istanbul on 15 December 1997 under the leadership of Necmettin Erbakan, prime minister of the 54th Government of the Republic of Turkey (Razzaqi, 2011:437). One of the main reasons why D8 countries are included in the model in this study is that all of these countries are homogeneous within the group of developing countries, that is, at levels of development. In addition, although they have a homogeneous structure at levels of development, the fact that some of the countries in this group of countries are energy-dependent and some are energy importers attributes particular importance to this study. In this respect, the findings that will be obtained after the analysis chapter of the study will also reveal the functionality of the hypotheses in theory about electricity consumption and economic growth. At the same time, the Kónya (2006) bootstrap panel causality test applied in the study is also important both for this subject and for this group of countries in terms of being the first study in the literature.

The research first reviews in depth previous empirical studies on the subject. After the review of the literature, data on economic growth and electricity consumption variables of the countries subject to analysis are introduced. Following the introduction of the data, information is given about the method of the Kónya (2006) bootstrap panel causality test used for analysis. After the methodology chapter, the findings are discussed. In the conclusion chapter, the findings are analyzed in detail, and economic and political inferences are suggested.

2. Literature Review

Energy consumption has been a vital factor in production for economic growth since the Industrial Revolution. The stagflation phenomenon experienced throughout the world, especially with the oil crisis of 1973, once again demonstrated the importance of energy and its effects on economic growth, and with this process, a significant increase was seen in the number of studies examining the relationships between energy consumption and economic growth. In the production processes, besides energy sources such as natural gas, oil, nuclear energy, and renewable energy, electricity has a special place in terms of being more widely used. In this context, studies on the economic growth of electricity consumption, which is one of the main inputs of production, also have a distinct frequency. It is observed that real GDP or GDP per capita variables represent economic growth in most of the studies conducted in this regard. Therefore, the concepts of electricity consumption and economic growth are used in the studies to be discussed in the literature review.

The first study to be examined in the literature review is Razzaqi's (2011) study; the only one carried out for D8 countries. Three main factors distinguish the study of Razzaqi (2011) from this study. The first of these is the period discussed, the second is the methodology, and the third is the variable of energy consumption rather than electricity consumption. The researcher studies the relationships between energy consumption and economic growth in 1980-2007 with VAR Granger causality test and Vector Error Correction Model (VECM). According to the findings of the study, the causal relationship between energy consumption and economic growth in Iran and Nigeria (the growth hypothesis), economic growth, and energy consumption in Bangladesh, Egypt, Malaysia, Pakistan, and Turkey (the conservation hypothesis) was determined in the short term. In Indonesia, no causality (the neutrality hypothesis) was found between the variables. In the long term, as in the short term, findings regarding the growth hypothesis in Nigeria and the conservation hypothesis in Egypt were acquired. On the other hand, it was determined that energy consumption in the long term increases efficiency in all countries except Egypt. The research results determine the evidence of causality in either one or both directions between energy consumption and GDP in all countries in both the long term and the short term, except for Indonesia in the short term.

Masih and Masih (1996), one of the other researchers who examined the relationships between electricity consumption and economic growth and included D8 countries in their models, in particular, studied the data of 6 Asian countries (India, Pakistan, Indonesia, Malaysia, Singapore, and the Philippines) using Granger causality test over the period of 1955 and 1990. Their research concluded that the conservation hypothesis is valid in Indonesia, and the feedback hypothesis is valid in Indonesia. The cointegration correlation between variables was not identified in Malaysia, and therefore no analysis was conducted for the causality relationship. In another study, Murry and Nan (1996) conducted a Granger causality test with the help of 1970-1990 data from 23 OECD countries, including Indonesia, Malaysia, Pakistan, and Turkey. They found evidence for the existence of the conservation hypothesis in Indonesia and the growth hypothesis in Malaysia, Pakistan, and Turkey. Asafu-Adjaye (2000) examined the data of the 1973-1995 period in India, Indonesia, the Philippines, and Thailand, Indonesia, with cointegration and error-correction modelling techniques and observed that the growth hypothesis is valid. Wolde-Rafael (2006) obtained data from 17 African countries, including Egypt and Nigeria, in the period of 1971-2001, and the findings of their study with the Toda-Yamamoto causality method indicated that the feedback hypothesis is valid in Egypt. Yoo (2006) found out that the conservation hypothesis is valid in Indonesia, and the feedback hypothesis is valid in Malaysia in his study using the VAR method with data from the period of 1971-2002 from Indonesia, Malaysia, Singapore, and Thailand. In another study, Chen et al. (2007), using data from the period 1971-2001 of 10 Asian countries, including Indonesia and Malaysia, reached the results of the growth hypothesis in Indonesia and the validity of the conservation hypothesis in Malaysia. Using the data of 1980-2003 of OPEC countries, including Indonesia, Iran, and Nigeria, and performing the ARDL bounds test and Toda-Yamamoto causality methods, Squalli (2007) identified a long-term relationship between economic growth and electricity consumption according to the bounds test results of all three countries. In the Toda-Yamamato causality test, the growth hypothesis was determined in Indonesia and Nigeria and the feedback hypothesis in Iran. Narayan and Prasad (2008) concluded the validity of the neutrality hypothesis in Turkey by using a causal bootstrapping method with data from 30 OECD countries, including Turkey, in the period of 1960 and 2002. In Asghar’s (2008) study, the findings of the Error Correction Model and Toda-Yamamoto causality test for 5 South Asian countries (Pakistan, India, Sri Lanka, Bangladesh, and Nepal) revealed that the conservation hypothesis is valid in Pakistan and Bangladesh. Öztürk and Acaravcı (2011) investigated the data of 11 Middle East and North Africa (MENA) countries, including Iran and Egypt, with the data of Autoregressive Distributed Lag (ARDL) bounds testing with the data of 1971-2006 period. In the findings of the study, no cointegration relationship between economic growth and electricity consumption in Iran was concluded. In Egypt, findings show the existence of the neutrality hypothesis. Hossain and Saeki (2011), on the other hand, carried out a study in South Asian countries (Bangladesh, India, Iran, Nepal, Pakistan, and Sri-Lanka) using the Granger causality test with the data of 1971-2007 and suggested that there is the conservation hypothesis in Pakistan and the growth hypothesis in Bangladesh. For Iran, the relationships between variables were found to be statistically insignificant. In his study, Abbas and Choudhury (2013), who involved Pakistan and India, which are among the countries with high population density, determined that there is a causality relationship from agricultural growth to agricultural electricity consumption (the conservation hypothesis) in Pakistan based on the monthly data for the period of 2009-2010. Finally, Kar et al. (2019) conducted a study on data from the period of 1970-2014 of 15 developing countries. The findings of the study showed that the growth hypothesis is valid in Indonesia, Pakistan, Malaysia, and Turkey.

There are studies that focus on the relationships between electricity consumption and economic growth in the context of the D8 countries. Studies conducted specific to Bangladesh found out the conservation hypothesis by Mozumder and Marathe (2007) and Amin (2008), and the growth hypothesis by Amin and Murshed (2017). In their study findings, Ahamad and Islam (2011) concluded results for the existence of a short-term growth hypothesis and a long-term feedback hypothesis between variables. Sarker et al. (2019) found that the feedback hypothesis is valid between variables in the long term, while Dey (2019) suggested that the conservation hypothesis is valid in the short term and the feedback hypothesis in the long term.

Sharaf (2017), who conducted a study for Egypt, obtained findings regarding the existence of the neutrality hypothesis in his study. Yoo and Kim (2006) determined that the conservation hypothesis is valid in Indonesia and Zamani (2006) in Iran. In addition, Zamani (2007) observed the feedback hypothesis between electricity consumption and agricultural sector value-added.

In the findings of the studies conducted for Malaysia, the researchers Chandran et al. (2010) and Thaker et al. (2019) determined the presence of a growth hypothesis, and Shaari et al. (2013) found a conservation hypothesis. Tang (2008) concluded that the feedback hypothesis is valid in Malaysia.

Akinlo (2009), Iyke (2015), Bekun and Agboola (2019), and Ali et al. (2020) determined the growth hypothesis for Nigeria, while Akinwale et al. (2013) observed that the conservation hypothesis is valid. Besides, Ogundipe and Adapa (2013) decided that the feedback hypothesis is valid, and Adenuga and Ochu (2013) obtained results regarding the presence of the neutrality hypothesis in the findings of their studies.

In Pakistan, Jamil and Ahmad (2010) and Shahbaz and Feridun (2011) found the conservation hypothesis in their studies, Aqeel and Butt (2001), Javid et al. (2013) and Ali et al. (2020) suggested that the growth hypothesis is valid. Shahbaz and Lean (2012) obtained findings for feedback hypothesis between variables, whereas Kumar and Begam (2019) reached findings of the neutrality hypothesis.

In studies specific to Turkey, Altınay and Karagöl (2005), Kar and Kınık (2008), Ağır and Kar (2010), Acaravcı (2010), Saatçi and Dumrul (2013), Eren et al. (2016), and Aydın (2018) determined that the growth hypothesis is valid, while Kapusuzoğlu and Karan (2010) and Özata (2010) found that the conservation hypothesis is valid. Yapraklı and Yurttançıkmaz (2012), Aslan (2014), and Öncel et al. (2017) observed that the feedback hypothesis was valid.

When the studies and findings in the literature review are evaluated in general, it can be argued that different results are acquired in various studies. The most important reasons for this are the differences between country groups, periods, methodologies, countries' levels of development, and energy dependence.

3. Research Data

In line with the objective of the study, the gross domestic product (LGDP) and electricity consumption (LEC) variables of the D8 countries

(Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey) taken from the World Bank Database are used in the research analyses. Since the most extensive time series of variables in the World Bank database is the period of 1971-2014, this period was included in the model. Descriptive statistics of the variables of countries are given in Table 1.

Table 1: Descriptive Statistics

Variables	**LGDP_BGD**	**LGDP_EGY**	**LGDP_IDN**	**LGDP_IRN**	**LGDP_MYS**	**LGDP_NGA**	**LGDP_PAK**	**LGDP_TUR**
Mean	24.6414	25.2127	26.5101	26.4251	25.2789	25.8777	25.1217	26.6872
Median	24.5811	25.2629	26.6205	26.3903	25.3510	25.7139	25.2347	26.6932
Max.	25.7136	26.2017	27.5714	26.9377	26.4736	26.8375	26.0506	27.6561
Min.	23.7901	23.9898	25.2756	25.8915	23.8489	25.4041	24.0400	25.7693
Std. Dev.	0.5693	0.6718	0.6545	0.2935	0.7853	0.42272	0.6219	0.53158
Jarque-Bera	2.7665	2.47493	2.3789	1.8613	3.0799	6.92253	2.9906	2.21648
J-B Prob.	0.25076	0.2901	0.3043	0.3942	0.2143	0.0313	0.2241	0.33013
Observ.	44	44	44	44	44	44	44	44
Variables	**LEC_BGD**	**LEC_EGY**	**LEC_IDN**	**LEC_IRN**	**LEC_MYS**	**LEC_NGA**	**LEC_PAK**	**LEC_TUR**
Mean	4.1226	6.522	5.0168	6.9655	7.2538	4.4077	5.5334	6.9084
Median	4.1542	6.56	5.315	6.993	7.2966	4.4671	5.8101	6.9839
Max.	5.7689	7.43	6.6993	8.0137	8.445	5.0549	6.1446	7.954
Min.	2.3661	5.285	2.6639	5.6136	5.7466	3.3523	4.5105	5.5065
Std. Dev.	1.0068	0.653	1.2828	0.6692	0.83	0.4243	0.5427	0.7255
Jarque-Bera	2.6039	2.3812	3.883	2.2156	3.4151	3.8763	4.972	2.747
J-B Prob.	0.2719	0.304	0.1434	0.3302	0.1813	0.1439	0.0832	0.2532
Observ.	44	44	44	44	44	44	44	44

According to Table 1, based on an average of 44 years, the highest gross domestic product is in Turkey, while the lowest one is in Bangladesh. Also, electricity consumption is highest in Malaysia, while the lowest consumption is in Bangladesh.

4. Methodology

This study tested the relationships between variables with the help of a panel causality test that was developed by Kónya (2006). The key reason for selecting this test is that the test reveals causality relations for each of the countries one by one; moreover, there is no need to perform a unit root and/or cointegration test first. However, the prior conditions for this test are the presence of cross-sectional dependence in models and the requirement for models to be in a heterogeneous structure. This is because, before the Kónya (2006) bootstrap panel causality test, we first tested the presence of cross-sectional dependence in the models. Secondly, we tested the homogeneity/heterogeneity of the slope coefficient in the models. Information on the related tests can be seen below.

4.1. Cross-Sectional Dependence Tests

We tested the relationships between variables with the help of Models 1 and 2. Before the cross-sectional dependence, first, these two models are estimated by the least-squares method; the presence of a cross-section is tested in the residual terms of $u_{i,t}$ and $e_{i,t}$ belonging to these models.

$$LGDP_{i,t} = \beta_0 + \beta_i LEC_{i,t} + u_{i,t} \quad (1)$$

$$LEC_{i,t} = \alpha_0 + \alpha_i LGDP_{i,t} + e_{i,t} \quad (2)$$

In the models, β_0 and α_0 are constant terms; β_i and α_i are slope coefficients. β_i shows the effect of a 1% change in LEC on LGDP; α_i shows the effect of a 1% change in LGDP on LEC. The i is the country dimension of the models; t is the time dimension of the models. The total number of countries (N) means that the total number of all i in the models are 8 countries; T indicates that the whole-time dimension is 44.

For example, in Model 1, the residual terms ($u_{i,t}$) of the model should be inserted in the model in the case of testing cross-sectional dependence. Afterwards, cross-sectional dependence is tested by producing Model 3.

$$u_{i,t} = \alpha_i + \beta_i' x_{i,t} + \varepsilon_{i,t}(3) \qquad (3)$$

$x_{i,t}$ in the model shows independent variables at the k × 1 dimension. There is $x_{i,t} = (u_{i,t-1}, \ldots u_{i,t-p})$ in cross-sectional dependence tests for the model. α_i is the constant term coefficient; β_i' is the slope coefficient. It is assumed that the residual term for each of the countries is ($\varepsilon_{i,t} = \varepsilon_{1,t}, \ldots, \varepsilon_{N,t}$) $\varepsilon_{i,t} \sim IID\ (0, \sigma_{i,\varepsilon}^2)$. Test statistics that are obtained in this way inform us about whether there is a cross-section with the help of the below hypotheses. Again, the below hypotheses are tested using the BPLM test of Breusch and Pagan, (1980); the CD_{LM} test of Pesaran (2004); the LM_{adj} test of Pesaran, Ullah, and Yamagata (2008); and the LM_{BC}[2] of Baltagi, Feng, and Kao (2012);

H_0: cov ($\varepsilon_{i,t}$, $\varepsilon_{j,t}$) = 0 or σ_{ij}=0 ve i ≠ j. (There is no cross-sectional dependence in Model 1.)

H_1 cov ($\varepsilon_{i,t}$, $\varepsilon_{j,t}$) ≠ 0 or σ_{ij}≠0 (There is cross-sectional dependence in Model 1.)

The probability values of test statistics can be reviewed when the hypotheses are determined. The H_0 hypothesis is denied if the probability values of the test statistics are lower than statistical significance levels such as 10%, 5%, and 1%. This refers to the presence of cross-sectional dependence in the model. Cross-sectional dependence is tested in Model 2 by making the same things for $e_{i,t}$ that is the residual term of Model 2. Cross-sectional dependence in the models means that a shock in one country will create a shock in other countries.

4.2. Homogeneity Test

The model has a homogeneous structure if the slope coefficients of each of the countries in the panel data are equal to a single slope coefficient. The model has a heterogeneous structure if the coefficients of each of the

[2] Since all these tests were applied in models, further information related to tests could not be given.

countries are different. Determining this situation is both econometrically and economically significant. First, tests change based on the homogeneity in a model whose importance is econometrically specified. Cointegration and panel causality tests can be used if the model is homogeneous, while second-generation panel cointegration and panel causality tests are used if there is no homogeneity. Regarding economic terms, comprehensive evaluations can be made by observing the similarities and differences of countries in the models if there is heterogeneity. This study used a homogeneity test developed by Pesaran and Yamagata (2008) and based on the random coefficients model. Unlike Swamy's (1970) study, the homogeneity test developed by Pesaran and Yamagata (2008) gives reliable results at larger N and T dimensions. We can say for this study that the T = 19 dimension is a long period in terms of panel data models.

H_0: $\alpha_i = \alpha,$ i = 1,…,N for all i. (Model is homogenous.)

H_1: $\alpha_i \neq \alpha_j,$ some of i ≠ j (The coefficient of at least one country is different. Model is heterogeneous.)

Pesaran and Yamagata (2008) suggest $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ [3] are asymptotically powerful to test these hypotheses. H_0 is denied if the probability values of these test statistics are lower than statistical significance values such as 10%, 5%, and 1%. This means that the slope coefficients of the models vary by country.

4.3. Kónya (2006) Bootstrap Panel Causality Test

The panel causality test developed by Kónya (2006;982) reviews relationships between variables based on the SUR developed by Zellner (1962). In addition, it is emphasized that the SUR estimator of Kónya is more effective than the ordinary least squares (OLS) estimator.

The SUR system that includes *LPGDP* and *LEC* variables whose causality relationships are analyzed is as follows:

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[3] Study of Pesaran and Yamagata (2008) can be reviewed for further information on test statistics.

$$\left.\begin{aligned}
LGDP_{1,\mathrm{t}} &= \varphi_{1,1} + \sum_{l=1}^{\mathrm{ml}_LGDP_1} \alpha_{1,1,l} LGDP_{1,\mathrm{t}-1} + \sum_{l=1}^{\mathrm{ml}_LEC_1} \beta_{1,1,l} LEC_{1,\mathrm{t}-1} + \xi_{1,1,\mathrm{t}} \\
LGDP_{2,\mathrm{t}} &= \varphi_{1,2} + \sum_{l=1}^{ml_LGDP_1} \alpha_{1,2,l} LGDP_{2,t-1} + \sum_{l=1}^{\mathrm{ml}_LEC_1} \beta_{1,2,l} LEC_{2,\mathrm{t}-1} + \xi_{1,2,\mathrm{t}} \\
&\ \ \vdots \\
LGDP_{N,\mathrm{t}} &= \varphi_{1,N} + \sum_{l=1}^{ml_LGDP_1} \alpha_{1,N,l} LGDP_{N,t-1} + \sum_{l=1}^{\mathrm{ml}_LEC_1} \beta_{1,N,l} LEC_{N,\mathrm{t}-1} + \xi_{1,N,\mathrm{t}}
\end{aligned}\right\} \quad (4)$$

and

$$\left.\begin{aligned}
LEC_{1,\mathrm{t}} &= \varphi_{2,1} + \sum_{l=1}^{\mathrm{ml}_LEC_2} \beta_{2,1,l} LEC_{1,\mathrm{t}-1} + \sum_{l=1}^{ml_LGDP_2} \alpha_{2,1,l} LGDP_{1,t-1} + \xi_{2,1,\mathrm{t}} \\
LEC_{2,\mathrm{t}} &= \varphi_{2,2} + \sum_{l=1}^{\mathrm{ml}_LEC_2} \beta_{2,2,l} LEC_{2,\mathrm{t}-1} + \sum_{l=1}^{ml_LGDP_2} \alpha_{2,2,l} LGDP_{2,t-1} + \xi_{2,2,\mathrm{t}} \\
&\ \ \vdots \\
LEC_{N,\mathrm{t}} &= \varphi_{2,\mathrm{N}} + \sum_{l=1}^{\mathrm{ml}_LEC_2} \beta_{2,N,l} LEC_{N,\mathrm{t}-1} + \sum_{l=1}^{ml_LGDP_2} \alpha_{2,N,l} LGDP_{N,t-1} + \xi_{2,N,\mathrm{t}}
\end{aligned}\right\} \quad (5)$$

l lag length represents the lag lengths belonging to ml_LPGDP and ml_LEC in the models. Equations 1–4 are used to test the causality relation from LEC to *LPGDP*; equation 5 tests the causality relation from *LPGDP* to LEC. These lag lengths are specified by a combination that minimizes the Akaike Information Criterion (AIC) and the Schwartz Information Criterion (SC). As Kónya (2006, p.980) mentioned, every equation system has a vector autoregressive (VAR) (by Sims [1980]) equation based on the number of countries (N). Just as being in VAR equalities, the SUR system has an obligation for variables to be steady or cointegrated. The reason for this is the simultaneous correlation between the countries' VAR models.

Wald test statistics are computed for each country's VAR equalities in a causality test. Just as in Kónya (2006), these test statistics are compared using critical bootstrap values. In short, the hypotheses can be summarized for each of the countries as follows:

H_0: *LEC* is not the Granger causality for *LPGDP* for any i country (Model 1); or, *LPGDP* is not the Granger causality for *LEC* (Model 2).

H_1: *LEC* is the Granger causality of *LPGDP* for any i country (Model 1); or, *LPGDP* is the Granger causality for *LEC* (Model 2).

5. Empirical Results

This part of the study shows the findings that were obtained using the methods above. The test results for cross-sectional dependence can be seen in Table 2.

Table 2: Cross-Section Dependence Test Results

Models	**Model 1**		**Model 2**	
Test	**Test Statistics**	**P-value**	**Test Statistics**	**P-value**
BP_{LM}	775.4206*	0.0001	686.7569*	0.0001
CD_{LM}	98.8092*	0.0001	86.9610*	0.0001
LM_{BC}	98.7162*	0.0001	86.8680*	0.0001
LM_{adj}	24.0536*	0.0001	24.3551*	0.0001
***** indicates the rejection of the null hypothesis at the 1% significance level.				

There is cross-sectional dependence in both Model 1 and Model 2. It is inevitable for a shock that occurs in one country in the world to affect other countries. This finding is not surprising. Moreover, this result proves the first condition required for the Kónya (2006) bootstrap panel causality test.

Table 3: Slope Homogeneity Tests Results

Models	Model 1		Model 2	
Test	**Test Statistics**	**P-value**	**Test Statistics**	**P-value**
$\tilde{\Delta}$	52.995*	0.0001	48.442	0.0001
$\tilde{\Delta}_{adj}$	54.855*	0.0001	50.142	0.0001
* indicates the rejection of the null hypothesis at the 1% significance level.				

Table 3 shows the homogeneity test results. The coefficients for both models vary from country to country; that is, they are heterogeneous in structure. This result provides the second condition required for the Kónya (2006) bootstrap panel causality test.

Table 4: Kónya (2006) Bootstrap Panel Causality Test Results

H_0: LEC is not the Granger causality for LGDP (Model 1)					
Countries	**Coefficients**	**Test Statistics**	**Critical Values******		
	LEC	**Wald**	**10%**	**5%**	**1%**
Bangladesh	0.027	2.102	4.410	6.299	11.172
Egypt	**0.164**	**4.579*** **	**4.342**	**6.214**	**11.089**
Indonesia	-0.022	1.045	4.537	6.818	15.945
Iran	**0.230**	**31.818***	**9.035**	**11.960**	**21.158**
Malaysia	**0.128**	**5.349*** **	**4.417**	**6.352**	**11.501**
Nigeria	0.041	0.739	4.289	6.095	10.921
Pakistan	-0.020	0.595	4.125	6.098	10.703
Turkey	0.111	1.352	8.560	11.667	18.691

H_0: LGDP is not the Granger causality for LEC (Model 2)					
Countries	**Coefficients**	**Test Statistics**	**Critical Values********		
	LGDP	**Wald**	**10%**	**5%**	**1%**
Bangladesh	0.491	7.650	11.847	15.367	23.703
Egypt	**0.395**	**8.461*****	**7.440**	**10.474**	**17.591**
Indonesia	**0.229**	**10.331****	**5.743**	**8.051**	**14.519**
Iran	-0.047	2.505	4.872	6.978	12.543
Malaysia	**0.295**	**9.316*****	**8.017**	**11.120**	**18.727**
Nigeria	**0.242**	**7.610*****	**6.340**	**8.970**	**14.997**
Pakistan	0.066	1.624	6.445	9.079	15.139
Turkey	-0.044	0.210	6.009	8.369	14.816

*,**, *** *, **, and *** indicate rejection of the null hypothesis at the 1, 5, and 10 percent levels of significance, respectively. **** The bootstrap is based on 1000 replications.

According to the results of the Kónya (2006) bootstrap panel causality test in Table 4, there is a positive and unidirectional causality relationship from *LEC* to *LGDP* in Iran and from *LGDP* to *LEC* in Indonesia and Nigeria. For Egypt and Malaysia, a positive and bidirectional causality relationship was determined between the variables, and no causality relationship was found statistically between the variables in Bangladesh, Pakistan, and Turkey. As the study results clearly indicate, both the existence of causality relationships and the coefficients of the relations vary in different countries.

According to Kónya (2006) bootstrap panel causality test results, it is found out that there is a positive and unidirectional causality relationship from electricity consumption to economic growth (the growth hypothesis) in Iran and from economic growth to electricity consumption (the conservation hypothesis) in Indonesia and Nigeria. For Egypt and

Malaysia, a positive and bidirectional causality relationship (the feedback hypothesis) was determined between the variables, while no causality (the neutrality hypothesis) relationship was found statistically between the variables in Bangladesh, Pakistan, and Turkey.

The findings of this study are in coincidence for Iran with Razzaqi (2011), for Indonesia with Masih and Masih (1996), Murry and Nan (1996), Yoo (2006), and Yoo and Kim (2006), for Nigeria with Akinwale et al. (2013), for Egypt with Wolde-Rafael (2006), for Malaysia with Yoo (2006) and Tang (2008), for Pakistan with Kumar and Begam (2019), and for Turkey with Narayan and Prasad (2008). There are no studies in the literature similar to the findings for Bangladesh alone.

6. Conclusion

In this study, the relationships between the D8 countries' gross domestic product and electricity consumption were investigated by using Kónya (2006) bootstrap panel causality test using data from the period of 1971-2014. According to the test results in the analysis chapter of the study, it was found that there is a positive and unidirectional causality relationship between electricity consumption in Iran and economic growth in Indonesia and Nigeria. Therefore, as a result of the findings, it is understood that while the growth hypothesis is valid in Iran, the conservation hypothesis is valid in Indonesia and Nigeria. In the results of the analysis, it was estimated that there was positive and bidirectional causality between both variables in Egypt and Malaysia. This finding indicates that the feedback hypothesis is valid

in Egypt and Malaysia. In Bangladesh, Pakistan and Turkey, it can be suggested that the neutrality hypothesis is valid in these three countries according to the test results, which statistically do not show any causality relationship between the variables.

The fact that the growth hypothesis is valid in Iran means that any shock in electricity consumption can significantly affect growth. As seen in Table 1, Iran has the second most electricity consumption among the D8 countries after Malaysia. From this point of view, reductions in electricity consumption and conservation policies in Iran may have a negative impact on economic growth. In Iran, which is the third-largest state with the largest oil resources in the world and the second-largest state with natural gas resources, newer and larger resources are still being discovered. Among OPEC, which is active in determining world oil supplies and therefore prices, Iran is the second-largest producer of oil and gas. In this context, it can be argued that Iran has the potential to increase its national interests and position in the power hierarchy by influencing the accumulation of international capital (Hürsoy and Orhon, 2012: 71). For Iran, which is not energy-dependent and has abundant energy resources, these results are remarkable. Iran has economic and political problems with many countries, especially the United States, due to both regional developments and its nuclear program. As a result of these results obtained from the analysis, it is estimated that this may have occurred because the United States has an isolated economy in the region due to international economic sanctions imposed against Iran. For Iran, whose economy is growing relatively while its energy resources and potential are growing, lifting international economic sanctions could become a great opportunity for Iran, which currently has to cope with economic contraction. Countries and oil companies that want to access to Iran's oil resources are also aware of this situation and are engaged in intense competition and cooperation among themselves (Host, 2017:2). As can be deducted from international economic sanctions, Iran's current energy use is mainly aimed at meeting domestic demand. The relative growth observed in its economy is again due to this domestic demand. At this point, Iran should first go on the path of resolving its existing problems with neighbouring countries by demonstrating a more conciliatory attitude. After that, it should seek ways to present its arguments to the world public opinion on the unfairness of international economic sanctions. In the event that international economic sanctions are lifted, thanks to Iran's existing energy wealth and economic capacity, it will open up new trade and energy routes for Iran, then the Middle East and Europe.

For Indonesia, the findings support the conservation hypothesis, which means growth increases electricity consumption. According to the World Bank data, for a developing country with approximately 5% growth, 4.5% unemployment, and 2.7% inflation rate in 2019, these data of Indonesia are also a sign that things are on the right track. Nevertheless, Indonesia is one of the fastest-growing economies in Asia and concentrated on producing high-tech products; therefore, it has the most basic need for energy. Energy dependency is one of the biggest problems for the Indonesian economy. This result is far from sustainable for the oil importer Indonesia, which has oil and gas reserves but does not have sufficient energy resources. The Indonesian government has acknowledged the importance of energy access, as contained in Indonesia's Energy Law No 30/2007 (Sambodo and Novandra, 2019:113). The Indonesian government has adopted policies aimed at improving energy access by establishing energy security through its medium-term development plan for the period 2014 and 2019. In addition, the government implements incentive policies for the use of renewable energy based on local resources (Sambodo and Novandra, 2019). In this respect, it is beneficial for Indonesia to concentrate on alternative energy sources to disburden its energy dependence and increase its electricity consumption. The fact that this problem has been identified by the Indonesian government and implemented long-and medium-term development plans on this issue is a good sign for the future of the Indonesian economy. Besides, the World Bank (2019) approved a substantial loan to enable Indonesia to have geothermal resources, one of the wealthiest renewable energy sources in the world.

In Nigeria, results have been collected for the validity of the conservation hypothesis. This hypothesis applies to countries with low energy dependence. Nigeria's economy appears to be predominantly dependent on oil revenues. Apart from oil, agriculture and trade by traditional methods also have an important place in the country's economy (Bıçakçı, 2019:7). The workforce employed in Nigeria's industrial sector is 12%, according to the World Bank database. The share of the industrial sector in domestic income is 27.4%. With a population of over 200 million, the agricultural sector, which employs 35% of Nigeria's labour force, has a share of domestic income of 21.9% in 2019. The agricultural sector has a significant employment share in the country. Nigeria's agricultural sector appears to have significant employment. On the other hand, security problems in Nigeria also negatively impact the economy. The Boko Haram rebellion, kidnappings, and the Niger Delta problem, where oil pipelines are often targeted, are among Nigeria's most important security problems. Additionally, Nigeria, one of the world's largest oil producers and one of Africa's largest economies, has been identified as the country where the largest number of people live in extreme poverty. The Nigerian economy, whose oil revenues account for about 75% of the federal budget, entered a recession in September 2017 for the first time in more than 20 years and has shown only modest signs of growth since then. While the administration's efforts to diversify the country's economic activities continue, there has been no improvement in unemployment and poverty. Unemployment is the biggest problem in Nigeria. About a quarter of the population is unemployed, and two-thirds of the population live below the poverty line (INSAMER, 2020). All these data indicate that Nigeria's social and economic problems cannot be solved with oil and gas revenues. First of all, it is necessary for the country to find a solution to the problem of unemployment. For this purpose, priority must be given to real sectors such as agriculture to realize diversified, inclusive, and sustainable development. In contrast to the oil and gas sector, increasing investment in Nigeria's agricultural sector, which provides the most jobs, could contribute to reducing poverty and inequality.

There are findings that the feedback hypothesis is valid in Egypt. It can be inferred from this case that Egypt, which has sufficient energy resources, has sufficient resources for its current economic activity capacity. However, considering Egypt's current economic capacity, two basic energy resources of oil and natural gas, young and mostly well-trained manpower and tourism opportunities, it cannot be suggested that macroeconomic indicators are very good (Ansarian, 2020: 45). On the other hand, in Egypt, whose real GDP grew by 5.6% in 2019, natural gas, tourism and construction sectors have been the main drivers of growth from a sectoral point of view. Egypt's unemployment rate is around 7.5%, and its non-oil exports are also slow (The World Bank, 2020). Besides, Egypt's increasing the capacity of the active sectors in the country's economy and the productivity of the idle sectors may have a jump-off effect on their economy, which is a significant threshold. The most basic requirement of Egypt, which is part of the developing country group, is the lack of existing capital accumulation. At this point, most foreign capital investments are of serious importance. One of the most important conditions for attracting foreign investors to domestic markets is the formation of stable political ground. The presence of coups in Egypt's historical past is likely to cause foreign investors to invest more cautiously in Egypt. Based on the World Bank data, especially since 2011, there has been a remarkable increase in foreign capital investment in Egypt. On the other hand, Egypt should also support its energy sources with other renewable energy sources. Although these existing energy sources seem to support the current economy, in the long run, this situation is far from sustainable.

The study's findings also revealed that the feedback hypothesis is valid in Malaysia. Based on da data in Table 1, Malaysia has the highest electricity consumption among the D8 countries during the period covered. Like Indonesia, Malaysia is among Southeast Asia's fastest-growing and leading countries in high-tech product exports. It is likely that such an economy has high electricity consumption. In terms of economy, Malaysia has achieved stability in its region and is a very good country with a level of prosperity. In a country with a global economic structure, the service sector, industry, agriculture, mining, and energy resources are important elements of the economy (Bulut, 2019:44). 23% of Malaysia's industrial output comes from the mining sector, which is mostly oil and natural gas production. Although Malaysia is a small-scale oil exporter, it is a major natural gas exporter. The country can meet more than 80% of its oil needs. Because the oil produced in the country is of high quality, exports are made, and domestic needs are met by imports (Koç, 2014:7). In addition to the existence of all this energy wealth, Malaysian governments have consistently given significant support to the energy sector in history (Razzaqi, 2011:455). It can be thought that the positive progress of macroeconomic performances of Malaysia, which has a stable economic and political structure and adopts the export-oriented industrialization policy, can be thought to contribute to the positive and stable policies in energy policies.

In Bangladesh, Pakistan, and Turkey, the neutrality hypothesis was found to be valid. In other words, there is no interaction between electricity consumption and economic growth. This result reflects that these three countries primarily have fundamental problems to increase their energy needs as well as their production capacity. Bangladesh is the country with the lowest income and lowest electricity consumption in this group of countries, as shown in Table 1. Bangladesh does not have enough energy resources nor adequate economic infrastructure in terms of production. Turkey and Pakistan also do not have energy resources, and they are among the energy importing countries. Although Turkey appears to be the country with the highest income according to Table 1 and the highest electricity consumption after Malaysia and Iran, this table shows the existence of significant economic infrastructure deficiencies in Turkey. A similar problem applies to Pakistan. Especially in Bangladesh, Pakistan, and Turkey, important structural reforms for both the industrial sector and the energy sector must be carried out urgently. Policies to reduce energy imports, which have the most negative effects on the balance of payments, should be implemented in these developing countries.

In a general assessment, D8 countries must first use their resources in the most efficient way, make savings, and produce goods and services that can be the subject of high value-added exports to complete their industrialization processes and become a part of the developed countries. In terms of energy demand, the governments of D8 countries should subsidize the companies in the energy sector, and the necessary steps should be taken by identifying deficiencies within the framework of cooperation between the public, private sector, and universities. Specifically, the geography and climate of this group of countries are well suited for renewable energy production. They can only ease energy imports, one of the most significant burdens on the nation's economies, through access to renewable energy sources. Countries with energy resources, on the other hand, should use these resources in the most efficient way and for the production of products with higher added value. In addition, energy supply countries should concentrate on sectors that will diversify their revenue items as well as energy revenues. It can be useful for the D8 countries to pursue a common policy that will benefit from each other's experience for economic growth and energy demand.

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