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ORIGINAL PAPER

Do Primary Energy Consumption and Economic Growth Drive Each Other in Pakistan? Implications for Energy Policy

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Abstract

Since energy supports the economic production activities and has been considered the engine of economic growth, it is of central importance to investigate their mutual relationships. We examine the causality between primary energy consumption and economic growth in Pakistan for the period of 1972 to 2015. We adopt a multivariate causality framework by adding primary energy consumption to labor and capital as input factors in the production model. The results of the Toda–Yamamoto Granger causality test confirm the existence of bidirectional causality between primary energy consumption and GDP, thereby validating the existence of the feedback hypothesis in Pakistan. The findings of the study call for the government to adopt policies for energy efficiency and expansion rather than energy conservation. Moreover, the renewable energy consumption share should be upscaled in the current energy mix to strengthen the economic activities by keeping the environmental sustainability objective as a top priority of the country.

Keywords Primary energy consumption · Economic growth · Granger causality · Bidirectional causal relationship · Energy efficiency

JEL Classification O13 · Q42

Introduction

Over the last three decades, energy has significantly contributed to the economic growth (hereafter GDP) and socio-economic development of both developed and developing countries (Jan and Akram 2018; Ahmad et al. 2021e; Satrovic et al. 2021; Shan et al. 2021). A growing body of literature provides evidence of an established relationship between energy consumption and GDP in different countries (Ahmad et al. 2019; Işik et al. 2020; Zhang et al. 2020; Iqbal et al. 2021). Yet literature does not provide a clear consensus on the exact nature of the relationship between energy use and GDP, providing mixed empirical results between the two. In this regard, some scholars support the idea that energy use promotes GDP (Umar et al. 2020, 2021c; Ahmad et al. 2021c; Su et al. 2021; Wang et al. 2021). On the other hand, some studies claim that energy use hampers GDP by inducing negative impacts in terms of its environmental costs (Rehman et al. 2019a; Ahmad et al. 2020b; Anser et al. 2021a; Chandio et al. 2021a). While some studies establish a unidirectional causality running from energy consumption to growth or vice versa (Alvarado et al. 2021; Can et al. 2021; Gao et al. 2021; Işık et al. 2021b), some others suggest a bidirectional relationship between the two (Ahmad et al. 2021d; Bibi et al. 2021; Ji et al. 2021b; Li et al. 2021).

Determining the key factors that affect the growth of an economy is a major concern of development economics (Ji et al. 2021a; Verbič et al. 2021). Prior to the 1970’s oil embargo and energy crisis, no due attention was given by conventional economists to the effective interrelationships regarding energy use and GDP. However, after the landmark publication by Kraft and Kraft (1978), intense research has been conducted to assess the empirical evidence employing

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Granger causality and cointegration models (Chandio et al. 2020; Rehman et al. 2020; Ahmad et al. 2021a; Anser et al. 2021b; Umar et al. 2021a).

In Pakistan, like many other countries, energy use and GDP growth are interrelated. Figure 1 illustrates that the periods of high energy consumption rates were followed by high GDP growth rates (Jan and Akram 2018). This shows that energy and growth complement each other. Nevertheless, Pakistan mostly relies on non-renewable resources to fulfill the energy needs of the population (Jan et al. 2017; Irfan et al. 2019c; Jabeen et al. 2021a). Fossil fuels, having economic and environmental shortcomings, comprise more than 88% share of Pakistan's primary energy consumption (Jabeen et al. 2020). Against the backdrop of the inflating prices and environmental risks associated with fossil fuels, the government is making all efforts to increase and diversify the energy mix to meet Pakistan's energy needs in a sustainable manner (Rehman et al. 2021a). The government is leaving no stone unturned to uncap the renewable energy potential of the country (Irfan et al. 2019b; Jabeen et al. 2019).

In view of the inconclusive findings, plenty of research has been conducted to probe the causal relationship between energy consumption and GDP. Basically, this research is the extension of Ahmad and Zhao's (2018) work. They conducted a causality analysis between energy investment and economic growth in China and identified the presence of a bidirectional causal linkage between the two. However, they opted for an energy investment variable that does not directly incorporate the impacts of energy consumption since countries may invest less in the energy sector and yet consume more energy by depending on importing energy products. Such a situation inspired us to revisit the problem and examine the existence and direction of causality between primary energy use and growth in Pakistan from 1972 to 2015. This study adopts a multivariate model to ascertain the relationship between energy and GDP in Pakistan. In recent literature, the multivariate analysis has dominated the bivariate analysis because the former offers multiple causality channels (Akadiri et al. 2020; Ahmad et al. 2021b; Umar et al. 2021b).

Given the foretold scenario, this study aims to analyze the causal linkages between primary energy consumption and the economic growth of Pakistan from 1972 to 2015. This study extends the empirical literature on primary energy consumption and economic growth nexus by re-examining their interrelationship. The contribution of this study is novel in several aspects. For instance, we determine the primary energy consumption–GDP relationship by taking labor and capital as additional variables and thereby evade the problem of specification error that could possibly arise by the omission of relevant variables from the model. Further, we use the Toda–Yamamoto (T–Y) causality test for detecting the direction of a causal relationship, which is robust to structural breaks and gives reliable results. Besides, the T–Y causality approach allows us to test for cointegration even if the variables are integrated of order $I(0)$ or $I(1)$ or the combination of both orders, i.e., $I(0)$ and $I(1)$. This approach can also be used, disregarding either the variables are cointegrated or not. Finally, this paper also provides country-specific policy implications for sustainable energy production and consumption in Pakistan.

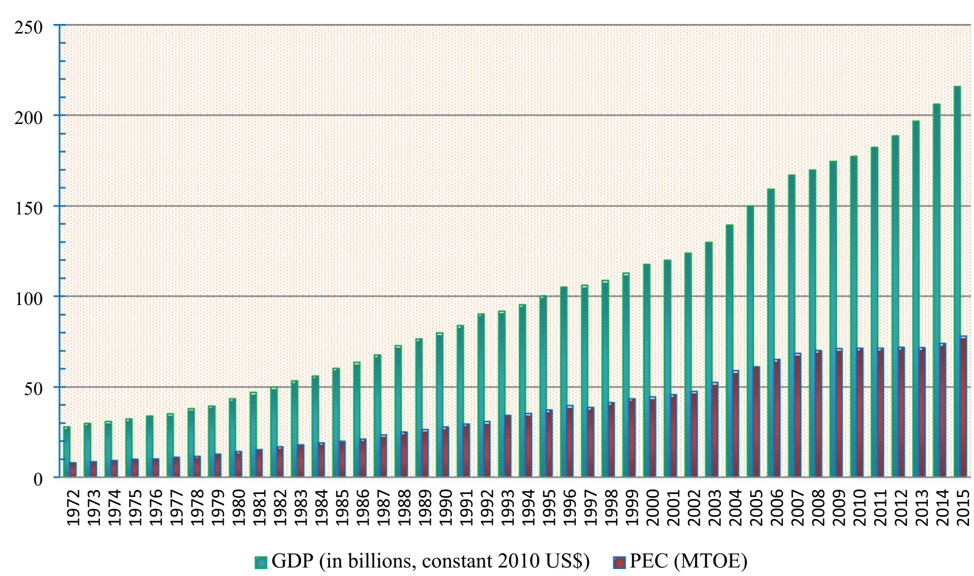

Fig. 1 Primary energy consumption and GDP growth rate in Pakistan, 1972–2015 (BP 2019; World Bank 2019)

Literature Review

A growing body of literature suggests that the energy consumption-economic growth nexus has been synthesized into four hypotheses. The first type of hypothesis, i.e., growth hypothesis, validates that there is a unidirectional causal relationship that runs from energy consumption to growth. According to the growth hypothesis, an increase in energy supply causes an increase in real GDP (Fatima et al. 2019; Ahmad et al. 2020a; Hao et al. 2020; Jabeen et al. 2021b). Using different methodological techniques, various researchers have found that energy consumption influences economic growth. For instance, Ahmad et al. (2020a) analyzed the energy-growth nexus for China and confirmed that energy consumption is an essential driver of economic growth. In another study, Fatima et al. (2019) employed a multivariate analysis and found a causal relationship that runs from energy to GDP in Pakistan. Similarly, Ouedraogo (2013) also confirmed the growth hypothesis for few selected West African states.

The second type of hypothesis, the conservation hypothesis, also confirms a one-way causality regarding energy consumption and GDP. However, the conservation hypothesis is validated if real GDP influences energy consumption, i.e., opposite to the growth hypothesis (Apergis and Payne 2009; Wu et al. 2020). Rehman et al. (2021b) investigated the existence of causality between GDP and energy use for the Pakistani economy. In another study conducted in Pakistan, Shahbaz and Feridun (2012) validated the existence of a one-way relationship regarding GDP and electricity consumption by means of the ARDL bound testing approach. Literature shows that both developed and developing countries provide enough evidence of validation of the conservation hypothesis (Narayan 2016; Hao et al. 2021; Ren et al. 2021). For example, Narayan et al. (2010) found that 20 Western European countries support the conservation hypothesis using different estimation techniques. Similarly, Kasman and Duman (2015) found the existence of a one-way causality running from GDP to energy consumption in the EU countries.

Contrary to the growth and conservation hypotheses, the feedback hypothesis supports the existence of bidirectional causality regarding energy use and GDP (Anser et al. 2021c). According to the feedback hypothesis, energy consumption and real GDP serves as complements to each other (Irfan et al. 2020). Işık et al. (2021a) used the demand and production models to test the causal relationship between real GDP, energy use, real energy prices, and capital for the United States, Mexico, and Canadian economies. Employing diverse econometric techniques, the study confirmed the existence of a bidirectional relationship between energy and GDP. Similarly, Akadiri et al. (2020) studied the link between global energy consumption and economic growth. The study used ARDL bound testing and Toda–Yamamoto (TY) causality approach and supported the feedback hypothesis at a global level. Similarly, Esseghir and Khouni (2014) confirmed the feedback hypothesis for Mediterranean states. The feedback hypothesis less emphasizes conservation policies and supports the adoption of energy efficiency policies (Irfan et al. 2019b; Ahmad et al. 2021a; Chandio et al. 2021b).

The fourth type of hypothesis, known as the neutrality hypothesis, does not support any causal relationship between energy consumption and growth (Fatima et al. 2021; Rehman et al. 2021c). In other words, it states that any change in energy supply will not affect GDP. For instance, Soytas et al. (2007) did not support any causal link between energy use and income in the US. Similarly, Shahbaz et al. (2015) confirmed the neutrality hypothesis for the focus variables in low-income countries. Also, Śmiech and Papiez (2014) found no nexus between energy consumption and GDP for the EU countries, thereby, supported the neutrality hypothesis. The neutrality hypothesis infers that energy efficiency policies should be preferred over energy conservation policies (Irfan et al. 2019a).

Most recently, Acheampong et al. (2021) analyzed the links between energy consumption and economic growth, in the presence of globalization, for 23 emerging nations from 1970 to 2015. In their study, they found the two variables interdependent, while globalization showed mixed results. Namahoro et al. (2021) studied the impact of renewable energy consumption on the economic progress of Rwanda during 1990–2015. They revealed a positive relationship between renewable energy consumption ion economic progress during the sample period. In their work, Salari et al. (2021) estimated the impact of energy utilization on the economic output of the US economy from 2000 to 2016. They disclosed the presence of the feedback hypothesis in their results. In the end, Li and Solaymani (2021) made use of the ARDL method to investigate the influence of economic growth on energy use. They found that economic growth was the main contributing factor to promote energy use in the Malaysian context from 1978 to 2018.

In light of the above-reviewed literature, we come to conclude that the empirical relationship between energy consumption and economic growth has been inconclusive. It could be associated with the use of different methodologies, data, and study contexts. Additionally, we found no research to investigate the interrelationship between primary energy use and economic growth in any context. Since primary energy consumption may involve relatively more serious adversities in terms of environmental damages, its effects on economic growth would be an interesting debate. Given this research gap, this study fills the literature gap by examining the linkage between primary energy consumption and economic growth in Pakistan.

Data, Model, and Methodology

For this study, we have used the annual time series data on real GDP, gross capital formation, labor, and primary energy consumption for Pakistan from 1972 to 2015. The data on real GDP and capital were retrieved from the World Bank (2019) database, whereas data on the labor force were acquired from various issues of the Economic Survey of Pakistan published by the Ministry of Finance, Government of Pakistan. Similarly, data on the primary energy consumption were obtained from the Statistical Review of World Energy (BP 2019).

Data and Variables

The GDP in constant 2010 (converted from PKR to US$ by using the 2010 official exchange rates (World Bank 2019) is the dependent variable. In contrast, primary energy consumption, labor force, and gross capital formation are the explanatory variables of the study. Description and measurement of the explanatory variables and their prior expectations are given in Table 1.

Model Specification

The study extended the basic production function containing only two variables, i.e., capital and labor, to the neoclassical aggregate production function by adding primary energy consumption as an additional input factor in the production model (Ahmad and Jabeen 2019). Such a multivariate analysis avoids the possibility of omitted variable bias, as in the case of bivariate analysis (Pesaran and Shin 1999). The basic functional form of the model adapted from (Wang et al. 2011) is given as follows:

$$Y_t = f(L_t, K_t, PEC_t) \tag{1}$$

where Y is the GDP, L is labor; K is capital; PEC is primary energy consumption, and t is the period from 1972 to 2015.

Table 1 Measurement and prior expectations of explanatory variables

Variable	Unit of measurement	Expected sign
Labor (L)	Million persons	+
Gross Capital Formation (K)	Constant 2010 US$	+
Primary Energy Consumption (PEC)	MTOE (Million Tons of Oil Equivalent)	+

All of the study variables are converted into log form to transform a nonlinear function into a linear function so that the variations in the data series can be eliminated (Oh and Lee 2004). The model after conversion to natural log form is specified as follows:

$$\ln Y_t = \beta_0 + \beta_1 \ln L_t + \beta_2 \ln K_t + \beta_3 \ln PEC_t + \varepsilon_t \tag{2}$$

where, β_0 is the intercept,$\beta_1$toβ_3 denote the coefficients, while ε_t is the error term.

Unit Root Tests

The study used the Augmented Dickey–Fuller (ADF) by Dickey and Fuller (1979), Phillips–Perron (PP) test by Phillips and Perron (1988), and Breakpoint (BP) test to avoid unit root problems. The study used two ADF models on each variable for testing unit roots in the series. The first ADF model includes both trend and intercept (Eq. 3), whereas, in the second model, the only intercept is included (Eq. 4).

$$\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + \sum\nolimits_{i=1}^{p} \beta_1 Y_{t-1} + \varepsilon_t \tag{3}$$

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum\nolimits_{i=1}^{p} \beta_1 Y_{t-1} + \varepsilon_t \tag{4}$$

where vY_t = 1st differenced value of a variable to be tested in time t; ∝ = intercept; β_t = trend in time t; Y_{t-1} = the first lag of variable; δ = parameter to be estimated; p = number of lags; ε_t = error term in time t. Our null hypothesis is $H_0 : \delta = 0$ which indicates that the series contains a unit root (nonstationary), and an alternative hypothesis is $H_A : \delta < 0$, which implies that the series does not contain a unit root (stationary). In order to reject the null hypothesis, the probability value of ADF, PP, or BP statistics should be less than the significance level. Furthermore, if the probability of trend is found significant at 1%, 5%, and 10% levels, then the result of the model with intercept and trend are accepted. When the trend is found to be insignificant, the decision about the stationarity of a variable is made on the basis of model results with intercept only.

Optimum Lag Selection: Akaike Information Criterion (AIC)

We used the Akaike Information Criterion (AIC) to choose the optimum number of lags for the models (Yuan et al. 2008). The AIC is selected because it is considered an efficient and accurate criterion for a small observation range (Liew 2004).

Causality Test

We also employed the Toda–Yamamoto causality test by Toda and Yamamoto (1995) to decide about the direction of causality among the study variables. T–Y test is selected for causality because this test can be utilized without considering the integration order of the selected variables (Toda and Yamamoto 1995). This means that the T–Y test can be applied if all variables are integrated at $I(0)$, $I(1)$, or some at $I(0)$ and $I(1)$. This test can also be applied irrespective of the existence or non-existence of cointegration (Soytas and Sari 2007). The general form of the basic equations to be estimated is as follows:

$$Y_t = \alpha + \sum_{i=1}^{h+d} \beta_i Y_{t-i} + \sum_{j=1}^{k+d} \beta_j X_{t-j} + \varepsilon_t \tag{5}$$

$$X_t = \alpha + \sum_{i=1}^{h+d} \gamma_i X_{t-i} + \sum_{j=1}^{k+d} \gamma_j Y_{t-j} + \varepsilon_t \tag{6}$$

where d is the maximum order of integration of the variables; h and k are optimum lags of Y and X, while ε_t is the error term.

Empirical Results

This section is devoted to explaining and interpreting empirical results, including unit root analysis, lag order selection, and causality analysis. It also discusses the results to open threads for policy implications.

Results of Unit Root Tests

To identify the order of integration, the results of ADF, PP, and BP tests on the integration properties of the real GDP (Y), labor (L), gross capital formation (K), and primary energy consumption (PEC) are presented in Table 2. The table illustrates that the unit root tests produce mixed results about the variables being $I(0)$ and $I(1)$. All study variables are tested for stationarity at level (raw data) and then on 1st differenced data with both ADF models.

The unit root test results demonstrate that among all variables, only ln$K$ is stationary at the level. However, the rest of the variables failed to reject the null hypothesis. Therefore, we applied the unit root test on variables taking the first difference. The unit root results indicate that all three variables (ln$Y$, ln$L$, and lnPEC) failed to accept the null hypothesis and became stationary at first difference.

Table 3 reveals the summary of the order of integration for each variable. This decision of the order is based on two conventional unit root tests (ADF and PP) without considering structural break and a BP unit root test that tests for

Table 2 Results of unit root tests

	Variable	ADF	PP	BP
Level				
Intercept	ln$Y$	−1.858222	−2.458600	−0.2666 (1992)
	ln$L$	−0.696935	−0.685076	−3.862556 (1996)
	ln$K$	−3.382422**	−1.752760	−4.532775 (2004)
	lnPEC	−3.524530**	−3.072874	−1.533191 (2008)
Intercept and trend	ln$Y$	−1.020664	−1.034616	−1.013616 (2009)
	ln$L$	−1.681005	−1.909039	−0.719640 (1996)
	ln$K$	−2.316333	−1.442031	−5.130789** (1991)
	lnPEC	−0.057661	−0.233366	−1.621183 (2002)
First difference				
Intercept	ln$Y$	−4.359346***	−4.412905***	−5.162705** (1992)
	ln$L$	−6.962707***	−6.950116***	−7.16885*** (2010)
	ln$K$	−5.752976	−5.793441***	−4.84811*** (1993)
	lnPEC	−4.474156***	−4.595796 ***	−5.926211** (2004)
Intercept and trend	ln$Y$	−4.781955***	−4.769202***	−5.161639 (2003)
	ln$L$	−6.909658***	−6.902974***	−8.75798*** (1996)
	ln$K$	−5.952431***	−5.952431***	−6.34264*** (2005)
	lnPEC	−5.451706***	−5.464755***	−4.496261* (2003)

***, **, and *Represent significance at 1%, 5%, and 10%, respectively. The years in the parentheses show break year

Table 3 Integration order of the variables

Variables	ADF	PP	BP
ln*Y*	*I*(1)	*I*(1)	*I*(1)
ln*L*	*I*(1)	*I*(1)	*I*(1)
ln*K*	*I*(0)	*I*(1)	*I*(0)
ln*PEC*	*I*(0)	*I*(0)	*I*(1)

a unit root in the presence of a single structural break. The table illustrates that different unit root tests yield mixed and somewhat contradicting results. For dependent variable ln*Y* and explanatory variable ln*L*, all three tests coincide in that they are stationary at the first difference and are integrated of order *I*(1). However, it is not the same for the rest of the explanatory variables, as the results of three unit root tests contradict. For variable ln*K*, ADF and BP unit root tests show the same order, i.e., *I*(0), whereas the PP test gives different results, i.e., *I*(1). For ln*PEC*, results of ADF and PP tests coincide, i.e., *I*(0), but the BP test is having a different result, i.e., *I*(1). Among these three tests, the results of the BP test are preferred due to the incorporation of a structural break in it. They hence are utilized to decide the integration order of variables. According to the BP unit root test, it is concluded that except for the explanatory variable ln*K*, all other variables are *I*(1).

Results of Optimum Lag Selection

The appropriate numbers of lags are selected through VAR lag order selection criteria. We used different lag order selection criteria to decide the lag length (Pesaran and Shin 1999). Table 4 illustrates the results of the VAR lag order selection criteria for the VAR model. As the table shows, the number of lags selected by AIC is two. The auto-regressive (AR) root graph and other relevant tests applications confirm that the model is dynamically stable at two lags and free from non-normality, serial correlation, and heteroscedasticity issues.

Results of Toda–Yamamoto Granger Causality Test

To investigate the direction of causal relationship, the T–Y Granger causality test is carried out by using a modified WALD (MWALD) test, following past studies (Alper and Oguz 2016; Chen et al. 2016). For the model used in this study, the maximum integration order is *I*(1), and the maximum lag length selected by AIC is 2 lags. The T–Y Granger causality test results with chi-square statistics and their corresponding probability values are presented in Table 5. The results suggest that: (i) In panel A, null hypotheses cannot be rejected for labor and gross capital formation because they do not cause GDP. Contrary to that, primary energy consumption does cause GDP, thereby rejecting our null hypothesis. (ii) In panel B, the null hypothesis cannot be rejected, which implies that GDP does not Granger cause labor. The null hypothesis is rejected at a 10% level, implying that the causality runs from gross capital formation to labor and primary energy consumption to labor, respectively. These findings show that gross capital formation and primary energy

Table 5 Results of T–Y granger causality test

	Dependent variable	Excluded variables	Chi-square	Probability
Panel A	ln*Y*	ln*L*	0.054602	0.9731
		ln*K*	0.629099	0.7301
		ln*PEC*	5.632594 *	0.0598
Panel B	ln*L*	ln*Y*	4.333219	0.1146
		ln*K*	5.572761*	0.0616
		ln*PEC*	4.957949 *	0.0838
Panel C	ln*K*	ln*Y*	18.77912***	0.0001
		ln*L*	3.438052	0.1792
		ln*PEC*	6.980445**	0.0305
Panel D	ln*PEC*	ln*Y*	6.210080**	0.0448
		ln*L*	0.232814	0.8901
		ln*K*	0.966603	0.6167

***, **, and *Significance at 1%, 5%, and 10% levels, respectively

Table 4 Var lag order selection criteria for GDP and PEC

Lag	LogL	LR[a]	FPE[b]	AIC[c]	SC[d]	HQ[e]
0	253.0916	NA	1.35e−09	− 11.90691	− 11.53076	− 11.76993
1	319.9906	114.2178	8.08e−11	− 14.73125	− 13.97895*	− 14.45730
2	332.6516	9.76359*	6.87e−11*	− 14.90984*	− 13.78139	− 14.49892*
3	338.7459	8.621167	8.16e−11	− 14.76809	− 13.26349	− 14.22020

*Indicates optimum lags selected by the criterion (at 5% level)

[a]Sequential modified LR test statistic (LR)

[b]Final prediction error (FPE)

[c]Akaike information criterion (AIC)

[d]Schwarz information criterion (SC)

[e]Hannan–Quinn information criterion (HQ)

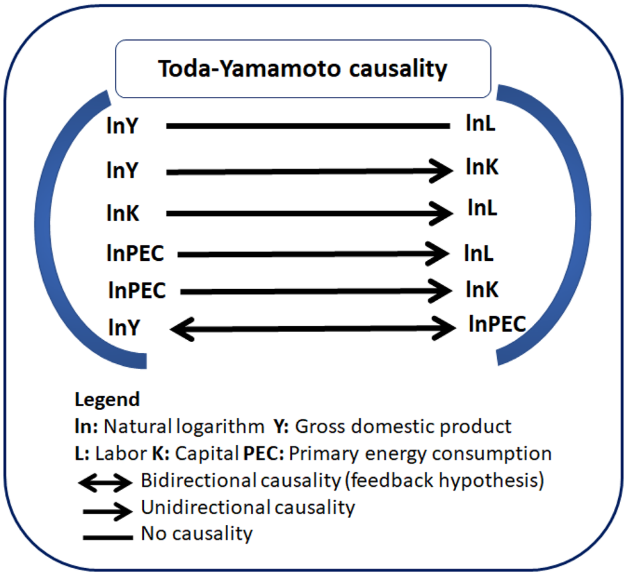

Fig. 2 The directions of causality among study variables

consumption play their part in Granger causing labor. Similar findings were recorded by Narayan and Singh (2007) for Fiji. (iii) In panel C, having gross capital formation as a dependent variable, only labor is not Granger causing gross capital formation, whereas GDP and primary energy consumption succeeded in rejecting the null of no-causality at 1% and 5% levels, respectively. It is implied that GDP and primary energy consumption are causing gross capital formation in the study period. (iv) Similarly, in panel D, with primary energy consumption as a dependent variable, only GDP is causing primary energy consumption significantly at a 5% level. For labor and gross capital formation, we failed to reject the null of non-causality. The results are consistent with Rehman et al. (2019b) in Pakistan and Anser et al. (2021b) in China.

A summary of the results outlined in Table 5 is illustrated in Fig. 2. After analyzing the causality results, it is concluded that there is no causal relationship between GDP and labor force in any direction. There is a unidirectional causality between gross capital formation and GDP. This implies that GDP causes gross capital formation, but gross capital formation does not cause GDP. Bidirectional causality is detected between GDP and primary energy consumption. Hence, on the basis of findings of the Granger causality test, the feedback hypothesis is confirmed for Pakistan. Similar results were presented by Rehman et al. (2019a), who confirmed bidirectional causality between energy consumption and GDP for Pakistan. Besides, studies by Filippidis et al. (2021) and Shakeel (2021) also validated the feedback hypothesis. The former found this evidence based on 200 global economies, while the latter found this result based on a nexus review of the energy consumption and economic growth.

Conclusions and Policy Suggestions

This study investigated the direction of nexus between PEC and GDP in Pakistan from 1972 to 2015. Three unit root tests, namely, Augmented Dickey–Fuller (ADF), Phillips Perron (PP), and Breakpoint (BP) tests, were utilized for testing the stationarity of the data series. Guided by the results of unit root tests for detecting the direction of causality Toda–Yamamoto Granger causality test is employed. Maximum Lags for the causality tests are selected by the VAR lag order selection criteria. The findings of the Toda–Yamamoto Granger causality test state that no causal relationship exists between GDP and labor. One-way causality is running from GDP to gross capital formation, gross capital formation to labor, primary energy consumption to labor, and primary energy consumption to gross capital formation, respectively. As far the direction of causality between energy consumption and economic growth, bidirectional causality is validated between primary energy consumption and GDP. Hence, on the basis of the Granger causality test, the feedback hypothesis is validated for the Pakistan economy. Given that primary energy consumption and GDP are having a bidirectional effect, it is recommended that the government focus on increasing energy supply by uncapping the indigenous energy sources so that the country gets rid of the decade-old energy crisis. Most importantly, it is suggested to upgrade the existing energy structure to increase the share of renewables in the current energy mix to strengthen the economic progress by protecting environmental sustainability domestically and internationally. Despite presenting interesting results, this study is confined to the primary energy-growth nexus; therefore, it would be interesting to touch on the environmental consequences brought about by primary energy use. It would enhance the empirical literature on primary energy use-environment-growth nexus to offer new policy dimensions in a relatively more robust policy framework.

Author Contributions SFD: Conceptualization and writing—original draft. IJ: Writing—review and editing, visualization, and software. MA: Writing—review and editing, handling revisions, and visualizations.

Data Availability All data generated or analyzed during this study are included in this article.

Declarations

Competing interests The authors declare that they have no competing interests.

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