AIMS Energy, 9(3): 516–533.
DOI: 10.3934/energy.2021025
Received: 10 November 2020
Accepted: 25 April 2021
Published: 30 April 2021

http://www.aimspress.com/journal/energy

Research article

Energy consumption, export performance and economic growth in a landlocked developing country: The case of Nepal

Resham Thapa-Parajuli[1,3], Saurav Aryal[1], Majed Alharthi[2] and Ramesh C Paudel[1,*]

[1] Central Department of Economics, Tribhuvan University, P.O. Box 3821, Nepal
[2] Finance Department, College of Business, King Abdulaziz University, Rabigh, P. O. Box. 344, Saudi Arabia
[3] Global Institute for Interdisciplinary Studies, P.O. Box 3084, Kathmandu, Nepal

* **Correspondence:** Email: ramesh.paudel@cdec.tu.edu.np.

Abstract: This paper examines the short-run and long-run relationship between energy consumption, export performance, and economic growth in a landlocked developing country, Nepal, from 1980 to 2018. We employ an Autoregressive distributed lag (ARDL) bounds testing approach to co-integration to investigate the relationship and role of energy consumption and exports on economic growth. The estimated results confirm the existence of a long-run relationship between economic growth and its regressors. The empirical estimation indicates the presence of a positive and statistically significant impact of exports on economic growth. Energy consumption and economic growth are positively associated; however, the coefficient is not statistically significant. Using the Granger Causality approach, the causality test reveals that there is unidirectional causality from energy consumption to economic growth, economic growth to export, and energy consumption to export.

Keywords: energy consumption; export; economic growth; ARDL

1. Introduction

A proper transition mechanism of energy with sustainable utilization and consumption of energy not only contributes to speed up the economic growth but also encourages the circular economy [1]. Therefore, the policy related to energy production and consumption is a very sensitive issue. The low consumption of energy may lower the speed of economic growth and overconsumption and irresponsible use of it may not contribute to a circular economy or even may go against the theory of the circular economy.

Generally, the level of energy consumption in advanced economies is relatively higher than those of developing economies. It reflects that energy is a source of economic activities, productivity growth, human resources development, and improving people's living standards. Therefore, energy consumption can play a vital role in accelerating economic growth directly, if not via export promotion indirectly. The energy consumption makes efficient use of other factors of production, hence higher growth. The East Asian Miracle has established the role of export performance in economic growth. In this context, other things remain the same; it is safe to assume that energy consumption and export play a pivotal role in boosting economic growth.

The relationships between 'energy consumption and economic growth' and 'exports and economic growth' have been the contesting research areas that several research works have been devoted to this area during the last decades. In this light, Dhungel declares a unidirectional causality from non-renewable energy consumption to GDP per capita in the case of Nepal [2]. However, Bhusal finds a bidirectional causality from oil consumption to economic growth in Nepal's case [3]. Other studies like [2,4,5] estimated the electricity consumption to GDP associations and confirm a unidirectional causality running from electricity consumption to GDP in Nepal. Moreover, the energy consumption and economic growth are co-integrated in the long run, and energy consumption impacts economic growth at a significantly positive level [5]. The energy consumption might transmit to economic growth through various channels; one channel might be the export. In this light, the electricity consumption substantially contributes in Nepal's export performance [6].

In the case of Brazil, the exports, electricity consumption, and real income have co-integrating relationship [7]. They use the ARDL bound testing approach and confirm the positive impact of export on real income in the long run. On top of it, electricity consumption has direct positive effects on economic growth in Brazil. Similarly, another paper by Sultan estimates the ARDL bounds test and the Johansen co-integration test to confirm the existence of a long-run relationship between electricity consumption, export, and growth in Mauritius [8]. This study finds that electricity consumption and exports both Granger cause economic growth in the long-run, ceteris paribus. And, electricity remains a significant causal variable in the short-run and cater to exports. In the case of South Asia, export and economic growth have a significantly positive co-integration coefficient [9]. However, the data in this paper were from Bhutan, Maldives, Nepal, and Pakistan only.

Many empirical studies focus either on the relationship between energy consumption and economic growth or the relationship between export performance and economic growth. There is a dearth of research explaining economic growth and its link with energy consumption and export juxtapose. But not such a study has been conducted in the context of Nepal. We also want to know whether energy consumption directly impacts economic growth or indirectly via exports.

There is contesting literature on how energy consumption transmits to economic growth. One possible transmission channel is governance. One of the possible channels could be through energy consumption as it contributes through firms' competitiveness increases [10]. In Portugal, policies that promote wine firm size, labor productivity, and wine promotion in third countries positively impacted firm level export performance [11]. The institutional quality matters [12], which channels via FDI. Similarly, the financial development channel is essential for energy consumption to get transmitted to growth transition [13]; and the institutional quality channel to reflect energy consumption into growth [14].

Thus, this study attempts to fill this gap by finding the causal relationship between energy consumption, export growth, and economic growth, and understanding energy consumption transmits to growth vis-à-vis export might have significant policy relevance in Nepal's case. Other studies either use energy consumption and growth only or energy consumption to export only. We are interested to see the causal association among export other two variables, namely growth, and energy consumption.

Analyzing the time-series properties of Nepal's annual data, this paper estimates both long-run and short-run relationships. We employ an Autoregressive Distributed Lag (ARDL) bounds test approach for co-integration. Also, we run a Pairwise Granger Causality test to gauge the directional causalities among the variables. The estimated results confirm a long-run relationship between economic growth and its regressors. The empirical estimation indicates the existence of a positive and statistically significant impact of exports on economic growth. The results also show that energy consumption positively contributes to economic growth, but this contribution is not statistically significant. Using the Granger Causality approach, the causality test reveals that there is unidirectional causality from energy consumption to economic growth, economic growth to export, and energy consumption to export.

This paper is structured as follows. The subsequent section is a brief discussion of the literature on energy consumption, export, and growth, followed by a description of section Three's methodology. The empirical findings and results are in section Four. The final section concludes the paper with some policy inferences.

2. Literature review

2.1. Energy consumption and economic growth

The empirical studies related to the association between energy consumption and economic growth date to the 1970s. One of the pioneering studies establishes a one-way causal relationship running from GDP to energy consumption in the US during 1947–1974 [15]. Other studies and their finding contradict their finding. They vary in terms of the methods and areas of coverages, countries, and regional cases. For example, Dhungel finds a unidirectional causality running from coal, oil, and commercial energy consumption to per capita real GDP throughout 1980–2004 in the case of Nepal [2]. Whereas a unidirectional causality running from per capita real GDP to per capita electricity consumption is estimated using the data coverage of 1980–2006 [4]. In both instances, the coefficients were supporting similar arguments. These studies confirm that per capita energy consumption, as an intermediate input, stimulates economic growth. Renewable energy further compliments the economic development, and it leads the economy towards sustainable development by energy conservation, reduction of Green House Gas emissions, and improvement in public health in Nepal. Another research paper analyzes the relationship between economic growth and oil consumption in Nepal for the period of 1975–2009. This paper reveals the existence of bi-directional Granger causality between oil consumption and economic growth in the short run as well in the long run [3].

A panel regression study estimate the panel granger casualty in South Asian panels, including Iran. It confirms the existence of unidirectional causality from economic growth to electricity consumption in India, Nepal, and Pakistan. Contrarily, there exists a unidirectional causality from electricity consumption to economic growth in Bangladesh. However, the study finds no causal relationship among the variables in the case of Iran and Sri Lanka. They report the Johansen-Fisher panel co-integration test results, which reveal the existence of a co-integration vector. The Granger causality results indicate the unidirectional causal relationship from electricity consumption to economic growth in the case of full panel estimation using data from 1971 to 2007 [16].

In one of the recent papers uses the south Asian panel for 2000–2011 and examines the causality between electricity consumption and gross domestic product of five countries. The paper conducts the panel unit root test and panel co-integration test and determines the long-run association among the variables. The co-integration test statistics confirm the long-run relationship or equilibrium between energy consumption and gross domestic product. The paper reveals a positive and significant impact of energy consumption on GDP in the case of South Asia; where a unidirectional causality runs from electricity consumption to GDP [5]. However, the electricity consumption and export performance of Nepal are strongly associated, but this study remains silent on whether there is bidirectional causality between these two variables [6].

The energy consumption from different sources of US energy has structural breaks, significantly alter the degree of persistence of most of the energy sources [17]. Similarly, the relationship between energy consumption and economic growth in Botswana is established in [18]. They use disaggregate level energy consumption components, namely: total energy consumption, electricity consumption, motor gasoline, gas/diesel oil, fuel oil, and liquefied petroleum gas. This study uses the ARDL-bound testing approach and found a causal flow from economic growth to energy consumption [18]. In this line, a recent Chinese example is available that examines the nexus of carbon dioxide (CO_2) emissions, energy consumption (EC), and gross domestic products (GDP), using an Autoregressive Distributed Lag (ARDL) bounds test approach of co-integration and error-correction model (ECM). The ARDL results confirm a long-run and short-run co-integration relationship between the variables. The relationship between CO_2 emissions and GDP is "relatively decoupling, and the EKC exists in China. Its CO_2 emissions are more explained by EC and contribute twofold to GDP. In the long run, there was significant negative causality from CO_2 emission and GDP to EC [19]. However, vehicular energy consumption that adds 40 percent of wheel emissions to the system as a cost to the economy, needs to be checked [20].

Another study estimates cross-country global panel data coefficients and concludes that the consumption of both renewable and non-renewable energy appears to have contributed significantly to the level of income across countries, implying that promoting renewable energy benefits economic development [21]. However, this paper is silent on the export route to GDP growth. Similar to energy consumption, resource rent also caters to growth. Institutions proved to play a role in determining whether a country is cured or blessed by resource abundance [22]. Long run Granger causality tests show a unidirectional causal relationship running from resource rents to GDP growth and development expenditure to GDP growth. The study recommends that the government manage natural resource rents with a policy framework supporting creating a virtuous economic circle between human development and economic growth. Similarly, some of the recent studies go further and explore transmission channels of energy consumption to growth. The institutional quality matters through the FDI channel [12]; the financial development channel through energy consumption matters to cater for growth [13]; and reveals and the institutional quality channel matters [14].

Based on the discussed literature' findings, we note that there is a distinct directional causality between energy consumption and GDP. However, many of the studies reveal that there exists either bidirectional or unidirectional causality between energy consumption and GDP. Therefore, finding the direction/s of these causalities and detecting the long-run and the short-run relationship between energy consumption and economic growth in the context of Nepal would be a remarkable contribution to the literature.

2.2. Exports and economic growth

The relationship between exports and economic growth has received considerable attention from trade and development economists, particularly since the East Asian Miracle (EAM). Notably, East Asian countries enhanced economic growth in their countries by improving export performance, including other policy reforms and productivity growth [23]. The scarcity and choice border of economics embedded into specialization based on labor division globally during the last two centuries. International trade develops as a useful tool for growth and development. Several rule-based trading platforms and networks were developed to strengthen international trade. In this context, countries with larger export share to GDP grew faster than other countries [24], which is in line with export based growth.

The growth of exports has a stimulating influence across the economy in the form of technological spillovers and other positive externalities. The expansion of international trade motivates specialized inputs which generate higher value addition to the economy [25]. Such trade-based growth leads to less protectionism and fosters efficiency-led growth. There can be several exports to growth transmission channels.

There can be different causal directions among the export and growth in different economies. In this context, there exists a one-way Granger causal relationship between GDP to Export in Canada for the period of 1870–1991 [26]. Another study by Thornton estimates the co-integration and Granger-causality tests in the case of Mexico from 1895 to 1992. The results show that real exports and real GDP were co-integrated, and there was a significant and positive Granger-causal relationship running from exports to economic growth [27]. One of the studies examines the Granger-causality among export and real GDP for seven south Asian countries. They found that the real exports and real GDP being co-integrated in the case of Bangladesh, Pakistan, and Nepal. The export leads to growth in Pakistan, Sri Lanka, and Bhutan, however, the converse is true in the case of India, Nepal, and the Maldives; growth-led exports [28].

A relatively recent study examines the South Asian export performance and growth for the period of 1990–2013. The paper deploys the co-integration and Granger-causality tests to examine the nature and direction of the relationship between export and economic growth. Their results show that there is unidirectional causation from economic growth to export for Bangladesh and India, whereas they have bidirectional causation in the case of Afghanistan and Sri Lanka. However, the export and the growth have no causation in the case of Bhutan, Maldives, Nepal, and Pakistan. One of the lesions from such contradicting results on causalities among export and growth might be the poor economic co-operation within the region that export-led growth is hardly in effect. Such limitations to growth through export might have reflected on other intermediate inputs like infrastructure, political stability, energy consumption, and others [9].

The export performance and role of quality of the institutional environment is characterized by a higher level of competitiveness and lower transaction costs. The export performance is considered as a reliable proxy to competitiveness [14]. However, the export performance is not a universal indicator of competitiveness, a finding that signals the need to apply other indicators, most notably, multi-factor ones. Some of the studies take household-level electricity consumption as proxy to analyze the city scale analysis [29], however, the availability of such data constraints many research works. Similarly, some of the studies used residential energy consumption to examine the shifts in energy consumption away from coal and toward electricity and gas [30], however, the study does not relate the findings towards the macroeconomic variables like export, import, and growth.

Another paper examines the trade balance and its effect on economic growth in European Union Countries; concludes that the deteriorating trade balance hinders economic growth [31]. They suggest further research considering other factors, such as the deficit's size and permanence. However, governance might improve the relationship between export performance and growth [10]. This paper analyses the nexus between exports established indicators of governance, and economic growth in Fiji, and concludes that the exports and government co-operate to promote economic growth. The export governance, coupled with other variables such as human capital, private investment, foreign aid, and policy environment, are also growth-enhancing in this small and vulnerable economy.

The export performance is directly linked with the firms' competitiveness [11]. Using panel data of Portuguese wine firms, this study shows that policies that promote wine firm size, labor productivity, and wine promotion in third countries positively impact export performance at the firm level. Age does not appear as a critical factor in the internationalization of Portuguese wine firms. In making firms competitive, the energy consumption technology used might be a crucial factor in the economy. This might be why some of the recent papers analyze the nature of the energy intensity and its outcome to pollution, one of the by-products finally society needs to bear.

2.3. Energy consumption, export, and economic growth

The export might connect energy consumption to growth transmission in various ways. Minimal studies are available that examines these three variables together. One of the papers examine the relationship between exports, electricity consumption, and real income in the case of Brazil [7]. Their bound testing procedures confirm the co-integrating relationship between exports, electricity consumption, and real income. According to their results, the export has a positive impact on real income in the long run, and electricity consumption has direct positive effects on economic growth. The paper is silent on the exact transmission channel to growth.

The ARDL bounds test and the Johansen co-integration test is deployed to evaluate the long-run relationship between export to GDP and electricity consumption to GDP in the case in Mauritius for the period of 1970–2009 [8]. This paper also examines the association between exports and electricity consumption. The multivariate Granger-causality analysis indicates that electricity and exports Granger cause economic growth in the long run. Electricity consumption remains a significant causal variable in the short run and promotes export. The empirical findings also suggest that the reduction in electricity consumption due to climate and clean energy policy may deter exports and economic growth. Their findings reveal that the real GDP per capita, capital formation, real exports, and electricity consumption are co-integrated, implying that there is long-run steadystate equilibrium among these variables. The long-run causality test concludes that real GDP per capita, capital formation, and real exports all adjust to shocks in the long-run co-integrating equation and are likely to be negatively affected by electricity conservation strategy. In the long run, the electricity consumption as well as real exports, both Granger-cause capital formation. Electricity consumption, however, is not found to be affected by shocks in the co-integrating vector. The short-run Granger causality test indicates that electricity consumption and investment Granger-causes per capita real income [8].

Mukhtarov and others investigate the relationship between energy consumption, financial development, economic growth, and energy prices in Kazakhstan, utilizing the VECM technique to the data spanning from 1993 to 2014 [13]. Estimation results reveal that there is a positive and statistically significant impact of financial development and economic growth on energy consumption while energy prices proxied by CPI hurts energy consumption in the long run for the Kazakhstani case which is in line with the expectations and with the theoretical findings.

The papers we reviewed are mostly related to the applied time series analysis. The nature of the variable, generally time series, and the nature of the research gab the papers are trying to fulfill might have explained it. However, some literature uses other methodologies besides time series econometrics and the ADRL model to establish the relationship between energy consumption and other macroeconomic variables, such as GDP, CO_2 emission, and others. On this front, Ardakani and Seyedaliakbar examines the relationship between energy consumption, economic growth, and carbon dioxide (CO_2) emission using a multivariate linear regression approach [32]. The paper formulated the quadratic functional form of the regression equations and estimated the coefficients accordingly. Moreover, this paper provides a comprehensive account of possible econometric methods to evaluate the relationship between economic growth and energy consumption is provided in this paper.

When the energy-economic growth research is related to the economics' distributional aspect, the researchers use either a micro-founded macroeconomic framework or a computable general equilibrium modeling approach [33]. This study uses a dynamic version of the Ramsey growth model, which gives analytical solutions to evaluate the economic cost. They investigate the effects of electricity distribution inefficiencies in Ghana's electricity sector on output, consumption, and investments. Inefficiencies are considered losses in transmission and distribution channels from the generator to the final consumer of energy leading to supply-demand mismatch (shortages and blackouts). Some of the papers use a computable general equilibrium modeling approach [34] and some deploy panel data econometrics [35,36], depending upon the nature of the research gab and data availability.

Whether electricity consumption transmits through export and promotes economic growth is not clear. The electricity consumption looks very pivotal for economic growth as well as for exports. There are limited empirical works on this front in the case of Nepal. For example, the causal relationship among energy, income, and pollution in the context of Nepal is examined but the issue of economic growth in line with export performance has been ignored [37]. An almost similar story was revealed while examining the causal relationship between energy consumption and economic growth in Nepal [38]. Therefore, we in this paper aim to contribute to this strand of literature analyzing the role of energy and exports in economic growth in the case of Nepal using the data for the period 39 years from 1980 to 2018 by detecting the direction of the causality and examining the association of these variables.

2.4. Policy and circularity in the energy transitions

The role of relevant policy and circularity in the energy transitions is important as the sound policy guides every stakeholder for the optimum and sustained utilization of the energy. The main issue in the energy transition is that how can we make the use of its more sustainable leaving as much as space for future generations. The concept of the circular economy encourages the rapid adoption of renewable energy technologies so that the sources of the energies are rationally used as discussed in [39].

The availability of energy and its consumption might reflect the economic growth and sustainable development subject to various factors. Among them, institutional factors might be the vital ones. Some countries are successfully transiting to growth and some are not. Literature suggests that institutional quality matters in this context as the spatial and socio-politically transformative potential of the transition towards the new energy system plays an important role [40]. The democratic energy decentralism facilitates the greatest potential to achieve ecological and social sustainability, also the scale of the energy system plays important role in reinforcing and reproducing democratic and just social relationships [41]. This relationship helps to maintain the circularity in the energy transition and circular economy. The biowaste-based energy transitions to the circular economy and suggest that drying and biowaste technologies increase the shift to bioethanol by almost five percent that motivates to use of more renewable energy contributing to the circular economy [42].

Most effective policy mixes vary across the scenarios and objectives suggesting that a simple one-fits-all approach does not work for a sustainable energy transition [43]. The green finance gap for the energy transition and suggest that a finance ecosystem approach is essential for financing low carbon investments in all levels to control the adverse impact of climate change [44]. In some cases, the private sector is playing an active role, however, in some cases, local governments are effective in innovating some sustainable energy uses. Information campaigns, scientific and technological collaborations, tax relief and production incentives, infrastructural investments, training courses, and simplification of administrative procedures are important facts to be considered in the energy transition journey [45].

Therefore, energy consumption alone might not be the right booster for economic growth, rather sufficient energy with the right policy and innovation are essential.

3. Research design

3.1. Model and variables

Since the data we are using in this study is annual time series, we check whether each variable is stationary. First, we estimate unit root tests, which is a standard procedure in time series analysis. In this process, we examine the stationarity of the variables using the Augmented Dickey-Fuller unit root test. The logarithm measure of energy consumption (LEC) is stationary at a level, and both logarithms of GDP (LGDP) and the logarithm of export (LEXPORT) are stationary at their respective first differences. Secondly, we select the optimal lag using the VAR lag selection. The Akaike information criterion (AIC) for the model suggests three optimal lags.

We perform the Granger-causality test to investigate the pairwise causality among the variables under consideration. The specification for the Granger-causality test is in Eq (1) to (3). Where K represents the number of optimal lag lengths. The intercepts and represented by $\alpha, \delta, and\ \vartheta$. Similarly, $\beta_i, \gamma_j, and\ \varphi_l$ are short-run dynamic coefficients of the model's adjustment to long-run equilibrium. The residual terms for each equation are represented by u_{it}.

$$\text{LEC}_t = \alpha + \sum_{i=1}^{k} \beta_i LEC_{t-i} + \sum_{j=1}^{k} \gamma_j LGDP_{t-j} + \sum_{l=1}^{k} \varphi_l LEXPORT_{t-l} + u_{1t} \quad (1)$$

$$\text{LGDP}_t = \delta + \sum_{i=1}^{k} \beta_i LEC_{t-i} + \sum_{j=1}^{k} \gamma_j LGDP_{t-j} + \sum_{l=1}^{k} \varphi_l LEXPORT_{t-l} + u_{2t} \quad (2)$$

$$\text{LEXPORT}_t = \vartheta + \sum_{i=1}^{k} \beta_i LEC_{t-i} + \sum_{j=1}^{k} \gamma_j LGDP_{t-j} + \sum_{l=1}^{k} \varphi_l LEC_{t-l} + u_{3t} \quad (3)$$

Lastly, we estimate the ARDL bound test to gauge the short and long-run relationship among the variables following the procedures [46]. This procedure has three significant advantages over the standard co-integration tests. Firstly, the ARDL does not need that all the variables in the same order, and it can be applied when the underlying variable is integrated of order one, order zero, or fractionally integrated. Secondly, the ADRL is efficient in small and finite sample data numbers. Finally, the ARDL technique gives unbiased estimates of the long-run model [47]. Therefore, our data structure and research problem demand the ADRL model. We present our benchmark model as in Eq (4):

$$\text{LGDP}_t = \alpha + \beta_1 \text{ EXPORT}_t + \beta_2 \text{LEC}_t + \epsilon_t \quad (4)$$

Then, this model would be converted into an ARDL version as in Eq (5);

$$\Delta LGDP_t = \alpha + \beta_1 LEXPORT_{t-1} + \beta_2 LEC_{t-1} + \sum_{i=1}^{39} \theta_i \Delta LGDP_{t-1} + \sum_{i=1}^{39} \gamma_i \Delta LEXPORT_{t-1} + \sum_{i=1}^{39} \delta_i \Delta LEC_{t-1} + v_t \quad (5)$$

where Δ stands for the first difference, t is the time period-year, and ϵ_t and v_t are the error terms in different models. The bounds test follows the joint F-statistics with its asymptotic distribution under the null hypothesis of no co-integration.

We employ autoregressive distributed lag (ARDL) approach to cointegration due to three important advantages: first, it provides both the long run and short run estimation from the same model, second, this test is more robust and performs better even in the small size of the sample, and third, this approach works fine with the mixed set of the variables with their different integration order, such as in our case that some variables are I(0) and rests are I(1) [48].

In the meantime, we are aware of the drawbacks of the ARDL approach. One of the important drawbacks is that it does not work when the integration order is greater than I(1), that is I(2) [49].

3.2. Data and their sources

The annual export and economic growth variable related are from the World Bank's world development indicators, freely available to download. Economic growth is a nominal measure. The GDP and exports are both measured in domestic currency (in 10 million Rupees). The energy consumption data is from various economic surveys, annual reports from the Ministry of Finance, Government of Nepal. The Energy Consumption is in tons of oil equivalent (TOE) measurement. We convert the variables into a natural logarithm scale when necessary, straightforward ways to capture elasticities. The sample period for the study spans from 1980 to 2018, that all the variables are in annual frequencies. The logarithm measure of economic growth, export, and energy consumption are denoted by LGDP, LEXPORT, and LEC, respectively, throughout this study. While estimating the elasticity coefficients, the LGDP is the dependent variable, others being explanatory variables as per necessary modification.

4. Results and discussion

We begin with the descriptive statistical explanation of the variables under consideration, followed by the summary of the findings from various time-series analyses and estimations. Table 1 presents descriptive statistics.

4.1. Empirical results

The summary statistics of the variables under consideration are in Table 1. The GDP has the highest standard deviation, followed by Export and Electricity consumption. All three variables are negatively skewed. The Kurtosis values of all three variables are less than three, signaling for the lighter tails than a normal distribution for all. Therefore, all three variables are similar in terms of their distribution.

Table 1. Descriptive statistics (All in logarithm scale).

Statistics	Gross Domestic Product	Electricity Consumption	Export
Mean	10.4378	8.9019	7.6610
Median	10.5440	8.9594	8.4541
Maximum	12.7554	9.3265	9.1810
Minimum	7.8450	8.4474	4.7292
Std. Deviation	1.4256	0.2491	1.4111
Skewness	−0.1573	−0.2832	−0.7761
Kurtosis	1.9518	1.9879	2.1312

In time series analysis, before running the causality test, we check whether the variables are stationary. For this purpose, this study uses the Augmented Dickey-Fuller test; the ARDL bound test assumes that the variables are I(0) or I(1). So, before applying this test, we determine the integration order of variables using the unit root tests. The objective is to ensure that the variables are not I(2) to avoid spurious results. In the presence of variables integrated of order two, we cannot interpret F-statistics's values [46]. The stationarity test results show that LEC is stationary at a level and LGDP and LEXPORT are stationary at the first difference at a 5% significance level.

Table 2. Unit Root test statistics (Augmented Dickey-Fuller Test).

Variable	ADF at Level		ADF at 1st difference	
	t-statistic	p-value	t-statistic	p-value
LGDP	−1.7462	0.7100	−4.8752	0.0019
LEC	−2.3540	0.0201	−11.4635	0.0000
LEXPORT	−0.8896	0.9460	−4.3795	0.0071

The Granger Pairwise causality test is done by using annual data from 1980 to 2018 with lag 2. The summary of the statistics is in Table 2, which reveals that there is a one-way causal relationship between energy consumption to economic growth, economic growth to export, and energy consumption to export. The p-values of all these associations are 0.0324, 0.0208, and 0.002, respectively; all lesser than 0.05. Therefore, the statistically significant level of one-way causality at a 5% level of significance. However, there is no statistically significant level of causality between economic growths to energy consumption, export to economic growth, and export to energy consumption with probabilities 0.3980, 0.2361, and 0.3935 respectively; all greater than 0.05 at a 5% level of significance.

Table 3. Pairwise Granger causality test.

Null Hypothesis	Observations	F-Statistic	P-Value
LEC does not Granger Cause D(LGDP)	36	3.8391	0.0324
D(LGDP) does not Granger Cause LEC		0.9494	0.3980
D(LEXPORT) does not Granger Cause D(LGDP)	36	1.5128	0.2361
D(LGDP) does not Granger Cause D(LEXPORT)		4.4023	0.0208
D(LEXPORT) does not Granger Cause LEC	36	0.9614	0.3935
LEC does not Granger Cause D(LEXPORT)		7.6220	0.0020

Evidence of unidirectional causality relationship between energy consumption to economic growth support existing literature [2,5]. The result of unidirectional causality from economic growth to export is the same as [28].

To find the optimal lag selection for the ARDL model, this study used VAR Lag Order Selection Criteria for optimal lag selection.

Table 4. Optimal lags criteria.

HQ	LogL	LR	FPE	AIC	SC	HQ
0	−32.0417	NA	0.0015	2.0024	2.1357	2.0484
1	135.5015	296.7908	1.73e-07	−7.0572	−6.5240*	−6.8731
2	147.4216	19.0722	1.49e-07	−7.2241	−6.2909	−6.9020
3	163.5549	23.0476*	1.02e07*	−7.6317*	−6.2986	7.1715*
4	171.9772	10.5879	1.12e-07	−7.5987	−5.8656	−7.0004

Table 4 represents the result of the optimal lag—different criteria of lag selection methods LogL, LR, FPE, AIC, SC, and HQ are reported. However, the most used criteria are AIC or SC. VAR shows optimal lag using AIC gives three lags, which is signaled by asterisks (*) and one lag with SC criteria. This information is used while estimating the elasticity coefficients later.

The result of the ARDL bounds test is shown in Table 5. Based on the critical values, there is a co-integrating relationship when the GDP is used as a dependent variable. Results of long-run relationships are sensitive to lag-length selected in the model [48]. This paper used AIC to select the optimal lag of variables included in the ARDL model.

Table 5. F-Bounds Test for ARDL.

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Significant Level	I(0)	I(1)
F-statistic	12.1991	10%	2.63	3.350
k	2	5%	3.10	3.875
		1%	4.13	3.875
Actual Sample Size (n) = 37				

Table 5 represents the result of the bound test. We applied a bound test to confirm either co-integration exists or not. Co-integration means a long relationship in the projected variable. Criteria of a bound test are if the F-statistic calculated value is more than the upper bound of at 1%, 2.5%, 5% & 10% level of significance and this concluded that there is a long-run relationship. The above table shows that the f-statistic value 12.1991 is more than all values of the upper bound. This indicates that co-integration exists when economic growth is used as a dependent variable at a 5% significance level. If the F-stat(bound test) calculated value more than comes more than the upper bound I(1)– co-integration exists- long-run relationship, then we can apply ARDL. If the F-stat value is lower than Lower Bound I(0) –co-integration does not exist we can't use ARDL. When the F-stat value is exactly or in between upper and lower bound values, this case is inconclusive. The energy consumption and economic growth were co-integrated in [5], however our findings indicates that a long-run relationship can be established when export variable is in the analysis.

4.2. Discussions

The information in Table 6 indicates the long-run elasticities of energy consumption and export with economic growth. Findings confirm that there is a positive but statistically not a significant relationship between energy consumption and economic growth at the five percent level of significance. The results also indicate that there exists a positive and statistically significant relationship between export and economic growth at a five percent level of significance suggesting that a one percent increase in export causes to increase the economic growth by about 0.18 percent holding other variables in the model constant.

Table 6. Long-run relationship coefficients.

Variable	Coefficient	Std. Error	t-Statistic	Probability
LEC	0.0143	0.0406	0.3534	0.7262
LEXPORT	0.1761***	0.0527	3.3435	0.0022
C	−0.0273	0.3639	−0.0749	0.9408

Note: *,**, and *** 10%, 5% and 1% level of significance.

The Conditional Error Correction on Regression is estimated, and the results are shown in Table 7. The elasticities coefficients in this table show two important results. In the short run, the estimated effect of energy consumption on economic growth is positive and statistically significant. In the short run, a one percent increase in the difference with one lag in energy consumption is associated with about a 0.15 percent increase in economic growth. The estimated effect of the difference in exports on economic growth is statistically significant. This gives about a 0.12 percent increase in economic growth if we increase one percent in energy consumption.

Table 7. ECM results.

Variable	Coefficient	t-Statistic	P-Value
C	−0.0181	−0.0727	0.9425
D (LGDP(-1))	−0.6643***	−4.7527	0.0000
LEC(-1)	0.0095	0.3553	0.7248
D (LEXPORT)	0.1170***	3.7237	0.0008
D (LEC)	0.8572	1.1300	0.2671
D (LEC(-1))	0.1501**	2.0420	0.0197

Note: *,**, and *** indicates for 10%, 5% and 1% level of significance.

The above pieces of evidence of the positive effect of energy consumption on economic growth in the long run support [5]. Studies on other emerging economy like brazil [7] found evidence of a co-integrating relationship between exports, electricity consumption, and real income by applying ARDL bound testing approach results in export has a positive impact on real income in the long run, and electricity consumption has direct positive effects on economic growth.

4.3. Diagnostic test

Some diagnostic tests are performed to determine the validity of the model and variables used in the ARDL bound test methodology. Accordingly, serial correlation, heteroscedasticity, and normality tests have been performed for the model and variables used in the study. Table 5 shows the results for the tests.

Table 8. Diagnostic Test.

Diagnostic Test	Test Statistics	p-value
Serial correlation LM	1.0887	0.3701
Heteroscedasticity	0.6468	0.6659
Normality Test	0.1899	0.9094

Source: Authors calculation.

According to the results in Table 8, the model does not contain serial correlation, normality, and heteroscedasticity problems. In the last stage of the ARDL application, CUSUM tests are performed to measure the stability of the coefficients and to determine whether there is a structural break in the model as a result of the analysis.

According to the Figures 1 below, the CUSUM and CUSUMSQ appear within the 5% confidence interval. These results accept the long-term relationship between variables. At the same time, these results also show the stability of the coefficients and the absence of a structural break in the model. CUSUM figures show that the ARDL bound test analysis in this study is verified as a whole.

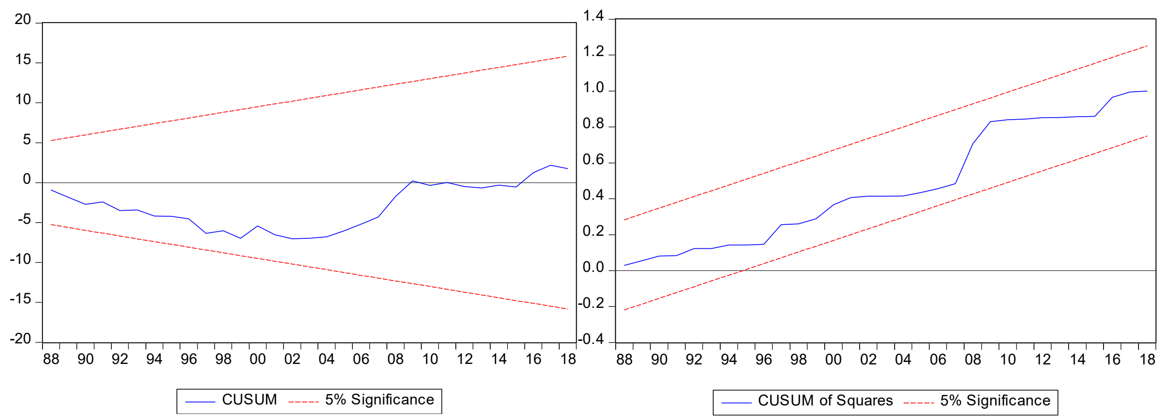


Figure 1. CUSUM and CUSUMSQ Plots.

5. Conclusions

This paper examines the association of energy consumption and exports with economic growth. We first analyze the time-series properties of the data, such as unit root testing that shows that the data of the economic growth and exports are not stationary at level, and they are stationary at first difference. There is a different indication of energy consumption, which is stationary at level. Therefore, this research applies the ARDL model to find out the co-integration between the variables using the bound test approach of F-statistic, which shows that the value of F-statistic is greater than all upper bound critical values. This gives the conclusion that economic growth is associated with energy consumption and export in the long term. The Pairwise Granger causality test shows that one-way (unidirectional) causality from energy consumption to economic growth, economic growth to export, and energy consumption to export.

This paper also establishes the importance of energy consumption and export performance in economic growth. Energy consumption has a positive effect on economic growth. The government may invest heavily in energy infrastructure and devise better energy conservation techniques, support the development of renewable energy, and being careful at the same time that such effects do not have negative efforts on economic growth. The results suggest that there has not been sufficient work to increase the supply and proper use of energy so that it would contribute meaningfully directly to economic growth. However, the results show that energy consumption has a strong contribution to export performance, which has a statistically significant contribution to economic growth. The nexus of energy consumption and export performance results are in line with [5,6] in the context of Nepal. Therefore, we can say that energy consumption contributes to economic growth via export performance. The results for export performance suggest that boosting exports can be a way to accelerate economic growth as it has a strong association with economic growth. The government may promote the private sector and reduce tariff barriers to increase exports.

In this paper, we simply estimate the association of energy consumption, export performance, and economic growth for both the long run and short run in the context of Nepal considering the time-series property of the data. One possible extension on this paper might come from work on the channel from which energy impacts economic growth documenting the important measures for circular economy in terms of the energy transition mechanisms.

Acknowledgments

We thank the handling editor of AIMS Energy and two anonymous reviewers for their quality comments and suggestion to improve the paper to this version. We appreciate their scholarship in the field of energy, trade, and economic growth. Saurav Aryal presented preliminary version at the 16th South Asian Economics Students' Meet-2020 held in Kathmandu, Nepal; and express his gratitude to the organizers and discussants for the invaluable suggestions.

Conflict of interest

The authors declare no conflicts of interest.

References

1. Tomić T, Schneider DR (2018) The role of energy from waste in circular economy and closing the loop concept—Energy analysis approach. *Renewable Sustainable Energy Rev* 98: 268–287.
2. Dhungel KR (2008) Regional energy trade in South Asia: problems and prospects. *South Asia Econ J* 9: 173–193.
3. Bhusal TP (2010) Econometric analysis of oil consumption and economic growth in Nepal. *Econ J Dev Issues*: 135–143.
4. Dhungel KR (2009) Does economic growth in Nepal cause electricity consumption. *Hydro Nepal: J Water, Energy Environ* 5: 37–41.
5. Dhungel KR (2017) Linkages between electricity consumption and economic growth: evidences from South Asian economies. *Hydro Nepal: J Water, Energy Environ*20: 18–22.

6. Paudel RC, Thapa-Parajuli R, Alharthi M (2020) Electricity Consumption and Export Performance: Evidence from Nepal. *Int J Energy Econ Policy* 10: 529.
7. Sami J, Makun KK (2011) The relationship between exports, electricity consumption and economic growth: empirical evidence from Brazil. *World Rev Bus Res* 1: 28–37.
8. Sultan R (2012) An econometric study of economic growth, energy and exports in Mauritius: Implications for trade and climate policy. *Int J Energy Econ Policy* 2: 225.
9. Kumar S, Rajesh K (2016) Causal relationship between export and economic growth: evidence from SAARC countries. *IOSR J Econ Finance* 7: 32–39.
10. Chand R, Singh R, Patel A, et al. (2020) Export performance, governance, and economic growth: evidence from Fiji-a small and vulnerable economy. *Cogent Econ Finance* 8: 16.
11. Faria S, Rebelo J, Gouveia S (2020) Firms' Export Performance: A Fractional Economic Approach. *J Bus Econ Manage* 21: 521–542.
12. Miao M, Lang QQ, Borojo DG, et al. (2020) The Impacts of Chinese FDI and China-Africa Trade on Economic Growth of African Countries: The Role of Institutional Quality. *Economies* 8: 20.
13. Mukhtarov S, Humbatova S, Seyfullayev I, et al. (2020) The effect of financial development on energy consumption in the case of Kazakhstan. *J Appl Econ* 23: 75–88.
14. Ruzekova V, Kittova Z, Steinhauser D (2020) Export performance as a measurement of competitiveness. *J Competitiveness* 12: 145–160.
15. Kraft J, Kraft A (1978) On the relationship between energy and GNP. *J Energy Dev*, 401–403.
16. Hossain MS, Saeki C (2011) Does electricity consumption panel granger cause economic growth in South Asia? Evidence from Bangladesh, India, Iran, Nepal, Pakistan and Sri-Lanka. *European J Soc Sci* 25: 316–328.
17. Adekoya OB (2020) Long memory in the energy consumption by source of the United States: fractional integration, seasonality effect and structural breaks. *Estudios De Economia (Econ Stud)* 47: 31–48.
18. Odhiambo NM (2021) Energy consumption and economic growth in Botswana: empirical evidence from a disaggregated data. *Int Rev Appl Econ* 35: 3–24.
19. Gessesse AT, He G (2020) Analysis of carbon dioxide emissions, energy consumption, and economic growth in China. *Agric Econ* 66: 183–192.
20. Krause J, Thiel C, Tsokolis D, et al. (2020) EU road vehicle energy consumption and CO_2 emissions by 2050-Expert-based scenarios. *Energy Policy* 138: 13.
21. Le TH, Chang Y, Park D (2020) Renewable and nonrenewable energy consumption, economic growth, and emissions: International evidence. *Energy J* 41: 73–92.
22. Mohamed ESE (2020) Resource rents, human development and economic growth in Sudan. *Economies* 8: 21.
23. Paudel RC (2014) Export performance in developing countries: A comparative perspective. Canberra: Arndt-Corden Department of Economics, Crawford School of Economics, and Government, ANU College of Asia and the Pacific.
24. Michaely M (1977) Exports and growth: an empirical investigation. *J Dev Econ* 4: 49–53.
25. Grossman GM, Helpman E (1991) Innovation and growth in the global economy: MIT press.
26. Henriques I, Sadorsky P (1996) Export-led growth or growth-driven exports? The Canadian case. *Can J Econ*: 540–555.
27. Thornton J (1996) Cointegration, causality and export-led growth in Mexico, 1895–1992. *Econ Lett* 50: 413–416.

28. Eusuf MA, Ahmed M (2007) Causality between export and growth: Evidence from South Asian Countries. *Jahangir Nagar Econ Rev* 19: 73–86.
29. Sheng WL, Zhang L, Ridley I (2020) The impact of minimum OTTV legislation on building energy consumption. *Energy Policy* 136: 13.
30. Xie LY, Yan HS, Zhang SH, et al. (2020) Does urbanization increase residential energy use? Evidence from the Chinese residential energy consumption survey 2012. *China Econ Rev* 59: 17.
31. Blavasciunaite D, Garsviene L, Matuzeviciute K (2020) Trade balance effects on economic growth: Evidence from European Union Countries. *Economies* 8: 15.
32. Ardakani MK, Seyedaliakbar SM (2019) Impact of energy consumption and economic growth on CO_2 emission using multivariate regression. *Energy Strategy Rev* 26: 100428.
33. Abrokwa KK, Dramani JB, Bhattarai K (2017) The effect of electricity technical losses on Ghana's economy: a simulation evaluation. *OPEC Energy Rev* 41: 286–317.
34. Cui Q, Liu Y, Ali T, et al. (2020) Economic and climate impacts of reducing China's renewable electricity curtailment: A comparison between CGE models with alternative nesting structures of electricity. *Energy Econ* 91: 104892.
35. Elheddad M, Thapa-Parajuli R, Alharthi M (2020) Foreign Direct Investment (FDI) and Natural Resources: Blessing or curse? Empirical evidence from the Gulf Cooperation Council (GCC). *J Rev Global Econ* 9: 232–241.
36. Thapa-Parajuli R, Devkota N (2015) Impact of climate change on wheat production in Nepal. *Asian J Agric Ext, Econ Sociol* 9: 1–14.
37. Bastola U, Sapkota P (2015) Relationships among energy consumption, pollution emission, and economic growth in Nepal. *Energy* 80: 254–262.
38. Dhungel KR (2007) A causal relationship between energy consumption and economic growth in Nepal. *Agricultural trade reform and poverty in the Asia-Pacific region: a survey and some new results Air pollution and income distribution in India Universal health-care demands in rural Northern* 14: 137.
39. Goddin JR (2020) The role of a circular economy for energy transition. *Mater Basis Energy Trans*, 187–197.
40. Juwet G, Ryckewaert M (2018) Energy transition in the nebular city: Connecting transition thinking, metabolism studies, and urban design. *Sustainability* 10: 955.
41. Thombs RP (2019) When democracy meets energy transitions: A typology of social power and energy system scale. *Energy Res Soc Sci* 52: 159–168.
42. Kokkinos K, Karayannis V, Moustakas K (2020) Circular bio-economy via energy transition supported by Fuzzy Cognitive Map modeling towards sustainable low-carbon environment. *Sci Total Environ* 721: 137754.
43. Falcone PM, Lopolito A, Sica E (2017) Policy mixes towards sustainability transition in the Italian biofuel sector: Dealing with alternative crisis scenarios. *Energy Res Soc Sci* 33: 105–114.
44. Owen R, Brennan G, Lyon F (2018) Enabling investment for the transition to a low carbon economy: government policy to finance early stage green innovation. *Curr Opin Environ Sustainability* 31: 137–145.
45. Falcone PM (2018) Analysing stakeholders' perspectives towards a socio-technical change: The energy transition journey in Gela Municipality. *AIMS Energy* 6: 645–657.
46. Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. *J Appl Econ* 16: 289–326.

47. Harris R, Sollis R (2003) Applied Time Series Modelling and Forecasting: Wiley: Chichester.
48. Bahmani-Oskooee M, Nasir ABM (2004) ARDL approach to test the productivity bias hypothesis. *Rev Dev Econ* 8: 483–488.
49. Nkoro E, Uko A (2016) Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *J Stat Econ Methods* 5: 63–91.

Annexes

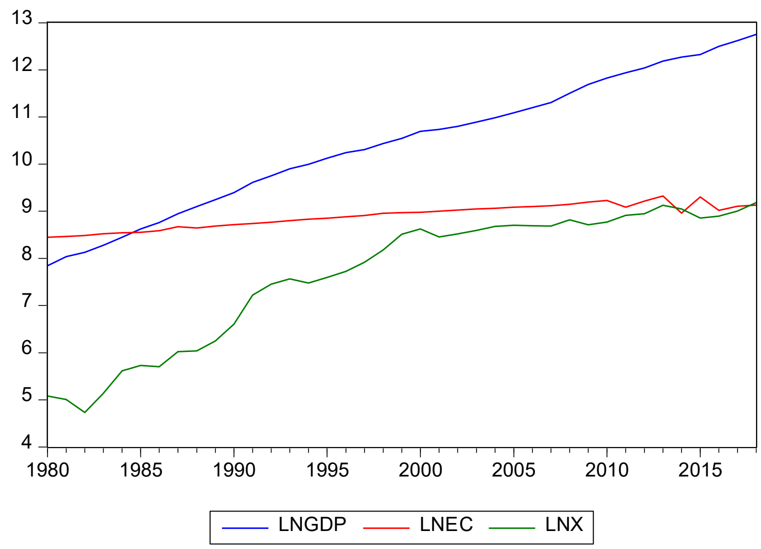
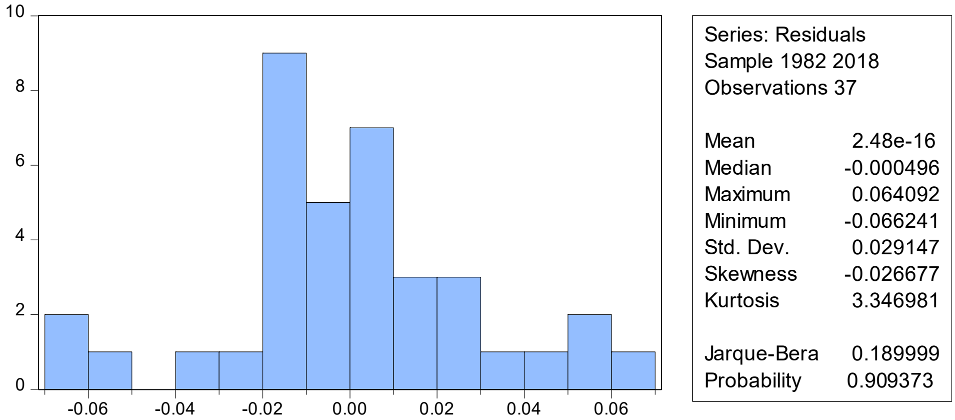


Figure A1. Trend of LNGDP, LNEC, and LNX.



Source: Author's calculation using eviews10

Figure A2. Jarque-Bera Normality Test.