Heliyon 5 (2019) e01904

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.heliyon.com

Estimating the causal relationship between electricity consumption and industrial output: ARDL bounds and Toda-Yamamoto approaches for ten late industrialized countries

A. Sankaran, Sanjay Kumar *, Arjun K, Mousumi Das

Department of Economics, Pondicherry Central University, India

A R T I C L E I N F O

JEL classification:
L16
L60
L94

Keywords:
Energy
Economics
Energy economics
Manufacturing industry
Manufacturing
Electricity consumption
Energy-led growth hypothesis
ARDL bounds test
Toda-Yamamoto approach
Late industrialized countries

A B S T R A C T

This research investigates the effects of electricity consumption (major independent variable), per capita income, real exchange rate, import and export on manufacturing output by using yearly time series data for the period of 1980–2016 with regard to 10 late industrialized nations. The ARDL bound testing approach, the way to deal with cointegration is applied to estimate the long-run connection between the variables. While, error correction method (ECM) is used to find the short-run dynamics. To test the causality among the variables, Toda-Yamamoto test is performed. The results demonstrate the existence of short-run and long-run relationship among the variables and Toda-Yamamoto causality results support the existence of growth, conservation, feedback and neutrality hypotheses for different nations. The difference in the results can be attributed to structural and macroeconomic parameters. In general, this research brings out a fresh lead of knowledge for late industrialized nations to strengthen their economic development through proficient utilization of energy consumption.

1. Introduction

Modeling the relationship function between energy consumption and economic growth is an important and ever interesting area of research. A good number of studies have been conducted in the context of connection between energy consumption and output by investigating the long-run and short-run dynamic inter-relationship as well as establishing causal links (even with the help of endogenous growth models). The studies have been pursued on the premises of developed, developing and newly industrialized countries. Hence, the existing body of literature portrays that the consumption of coal, petrol, thermal power, oil resource, natural gas and electric power has its direct bearing on economic development of the nations in general and every segment of the economy in particular. As pointed out by various research studies, energy consumption is a fundamental and indispensable input of production (Asafu-Adjaye, 2000; Lee and Chang, 2008; & IAEA, 2009). Using this instrument, a country can increase the production of goods and services thereby enhancing the income and economic growth. The outcome of research works conducted by Stern (2000), Shiu and Lam (2004), Altinay and Karagol (2005), Wolde-Rufael (2006), Yaun et al. (2007), Chebbi and Boujelbene (2008), Odhiambo (2009), Apergis and Payne (2010a,b), and Iyke (2015) for different periods using different types of econometric models on dissimilar data set indicate that energy is a powerful source to execute the production process, increase the volume of production, attain efficiency, enhance the welfare of the nation and ultimately to achieve a paramount economic development.

1.1. Energy and economic growth

A group of scholars conducted their research on an *individual country* in order to find the casual relationship between energy consumption and economic growth. The production function technique applied on **Canadian's** statistics by, Ghali and El-Sakka (2004) revealed that energy consumption contributed significantly to attain economic growth. The same production function model was applied by Cheng (1997) on **Brazilian** economy to examine the presence of relationship between energy

* Corresponding author.
E-mail address: sanjay.eco54@gmail.com (S. Kumar).

https://doi.org/10.1016/j.heliyon.2019.e01904
Received 10 March 2019; Received in revised form 6 May 2019; Accepted 3 June 2019

consumption and economic growth. Also, the result of the study coincides with that of Ghali and El-Sakka (2004). The energy influenced economic growth was found in **Turkey** by Soytas et al. (2001) and Altinay and Karagol (2005) for different periods by applying advanced models for estimation. In two different studies conducted in **Chinese** and **South Korean** by Wang et al. (2011) and Glasure (2002) respectively found that the causality runs from energy consumption to the growth of the economy. The experiment of co-integration and Granger causality by Rahman and Amin (2011) for **Bangladesh** supported the energy driven hypothesis. Whereas, the ARDL and causality estimation proposed by Siddiqui (2004) for **Pakistan** data determined the existence of energy led-economic growth. A comprehensive assessment conducted by Yang and Zhao (2014) attained the result in favor of energy driven growth in India.

1.2. Multi-country studies

In developed countries, quite a sizable number of empirical studies (Kraft and Kraft, 1978; Belke et al., 2011; Magazzino, 2015) have been attempted to demonstrate the nexus between energy consumption and economic growth. Among the existing multi-country studies, Narayan and Smyth (2008) found that the causality was visible for G-7 countries for the period from 1972 to 2002, i.e., causality relationship running from energy consumption to growth of GDP. In a comprehensive research work by Apergis and Payne (2009) based on six Central American countries for the period from 1971 to 2004, reached the conclusion that evidently perceivable unidirectional causality had escalated from energy consumption to real output. Also, Mohammad and Parvaresh (2014) proved the existence of both long and short-run dynamics between energy consumption and output in 14 oil-exporting countries. Further, the result confirmed the presence of causal relationship running from energy consumption to economic growth over the study period between 1980 and 2007.

Among the existing studies in the Asian context, the co-integration and Error-correction exercise of Pradhan (2010) determined that there was an energy induced economic growth in SAARC. Also, the findings by Pastén et al. (2015) for 16 Latin American countries the data from 1971 to 2001 revealed that the energy-driven growth existed in those nations in the long-run. A study undertaken by Lau et al. (2011) with a special focus on Asian countries indicated that energy performed as a powerful instrument to attain economic growth in the short-run. Chiou-Wei et al. (2008) found the validity for energy driven economic growth in Taiwan, Malaysia, Indonesia, and Hong Kong for the period from 1954 to 2006. By applying ARDL Bound test on India, Bangladesh, Pakistan and Sri Lanka, Khan and Qayyum (2007) concluded that the causality has been running from energy consumption to gross domestic product over the period under study.

1.3. Energy and industrial output

Classical economists failed to recognize energy as an important factor of production. In the modern world, energy use has been an integral part of economic growth (Yu and Choi, 1985; Shiu and Lam, 2004; Wolde-Rufael, 2004; Chang, 2010; and Velasquez and Pichler, 2010) in general and industrial development in particular (Hondroyiannis et al., 2002; Karumba, 2012; Patrick, 2014). Unlike Classical economists, Alam (2006) opined that, energy performs as a main instrument in converting raw materials into consumable commodities in the process of manufacturing. This sector consumes approximately one-third of the total energy produced in the world (Polemis, 2007). Hence, in the present context, the association between electricity consumption and industrial development is a debatable area of interest not only in developing nations but also in developed nations. Researchers redirected their attention to find the long-run and short-run relationship between electricity consumption and industrial development.

Among the available research studies, Parker and Liddle (2016) highlighted the significant role played by the electric power in the manufacturing sector, while examining the liaison between energy efficiency and energy consumption in manufacturing sector with respect to the OECD countries. The causal relationship between electricity consumption and industrial output for the period of 37 years from 1960 to 1996 was examined by Hondroyiannis et al. (2002) in Greece, and fount the bi-directional causal relationship between industrial output and electricity consumption. Sari et al. (2008) found that causality flows from industrial output and employment to energy consumption from various sources, including electricity, in the economy of US. In a recent study, Tapsin (2017) checked the long-run relationship between industry output and electricity consumption in Turkey using the time series data set for the duration of time from 1970 to 2015. By employing panel cointegration test and error correction model, he found that there is a bi-directional causality between these variables in the long-run. Using Nigeria data for the period from 1980-2013, Hassan (2016), found the bi-directional relationship between electricity consumption and manufacturing output. By applying VECM model for Kenya data for the period from 1970-2008, Karumba (2012), concluded that there was a uni-directional causality escalating from the output of manufacturing sector to electricity consumption.

The bounds test procedure of Sami (2012), in the case of Philippines offered the result that there was a long-term relationship between electricity consumption and growth in industry. Mawejje and Mawejje (2016) estimated the causal relationship between electricity consumption and sectoral output in Uganda and found that there was a uni-directional causality running from former to latter. The survey study pursued by Patrick (2014), concluded that, the electricity consumption had positively affected the manufacturing sector in Ghana. In order to find the long-run relationship between manufacturing value added and electricity consumption, Olufemi (2015) and Bernard and Obio (2016) applied different types of econometric tools such as Johansen co-integration and vector error correction model in Nigeria and found the electricity induced industrial growth. In the seminal research, Alley et al. (2016) reached similar conclusion for the same country for the period from 1980 to 2013. The research finding of Olufemi (2015) corroborated the recent study conducted by Abokyi et al. (2018) through the ARDL bounds test for the period from 1971-2014 for Ghana.

1.4. Manufacturing sector and open economy

In an influential research work, Kumar et al. (1999) elaborated the role of importing technology in augmenting the production and productivity of Indonesian manufacturing industry. Eaton and Kortum (2002) discussed the role of trade and new technology benefits for manufacturing sector based on absolute and comparative advantage theories for 19 OECD countries. Liu and Buck (2007) elaborated on International technology spillover (imports) and its accomplice indigenous innovative performance that jointly determines the performance of high technology industries in service sector. Real exchange rate acts as an international demand and supply shock which influences import of raw materials and export of output by altering international prices. Branson and Love (1988) discussed this in the context of US, while Ekholm et al. (2012) identified exchange rate pass through effect on manufacturing output using three major channels. Lai Yew Wah (2004) focused on sustainable economic growth experience of Malaysia on the wings of early industrialization where export-led growth and domestic demand-led growth were found valid at least in the short-run.

1.5. Energy and economic growth: four major hypotheses

Four hypotheses are explained to be relevant in describing energy-growth connectivity namely (1) growth hypothesis (2) conservation hypothesis (3) feedback hypothesis and (4) neutrality hypothesis. The growth hypothesis pinpoints energy consumption as a vital factor for economic growth. The hypothesis explains how reduction in energy has got a negative impact on GDP—in a nutshell, the economy is energy dependent. The conservation hypothesis paints a scenario where there is a unidirectional causality emanating from economic growth to energy use. So, the implication is that policy to reduce energy demand may not culminate into having any impact on economic growth. The feedback hypothesis implies bi-directional causality i.e., energy and economic growth have a symbiotic relationship. Neutrality hypothesis negates any kind of relation among growth and energy and thus considers them as an independent factor (Belke et al., 2011).

As a whole, while examining literature reviewed above, apart from energy, some other variables are also found playing a major role in determining the manufacturing output, such as import as a vehicle of technological transfer, export representing international demand, exchange rate carrying international supply and demand shocks, and domestic demand as well. The fundamental reflection is the realization that energy is a major input for all manufacturing production. While going through the existing studies, the researchers found that the context of discussing the association between energy consumption and manufacturing output in a group of late industrialized countries[1] is missing and thus found to be a gap in the research. The late industrialized countries are in a stage of transition and incur some structural changes in favor of industrialization. So, how energy-manufacturing output relations work in the open economic contexts of such countries deserve special attention.

The present study involves a detailed analysis of the nexus between electricity consumption and manufacturing value added for ten late industrialized countries along with the presence of control variables such as per capita income, imports, exports and real exchange rate. The additional purpose of the study is to test and understand the relevance of various hypotheses mentioned above. Hence, the study contributes a piece of knowledge towards the existing body of literature and makes the industrialists, electricity authority, academicians, governments, and policy makers of the late industrialized nations to understand about the degree of electricity dependency rate by the manufacturing sector. The present paper has two specific objectives which are as follows: (a) to understand the relation between manufacturing value added and electricity consumption in the presence of certain control variables, and (b) to have an empirical analysis of the relevant hypotheses explaining energy growth nexus and suggest policy recommendations on the basis of the evidence. Hence the novelty of the article is that this is the first systematic work on the relationship between manufacturing output and electricity consumption with special reference to the late industrialized nations in a comparative economic perspective. Further, this study offers interesting insights into effective energy policy-making for late industrialized nations that may help to enhance their economy and address their long-pending socio-economic issues.

The rest of the paper is framed as follows. Data and estimation methodology employed are discussed in Section 2. Section 3 presents the empirical results and discussions. Finally, the conclusion and policy suggestion are presented in Section 4.

2. Materials & methods

In order to examine the relationship among the variables, the study used annual time series data from 1980 – 2016 for ten late industrialized countries. These nations and periods of the study have been selected based on the availability of the data. In this study, the manufacturing value added (LNMVA) is the dependent variable and electricity consumption (LNELEC) is the major independent variable, while per capita income (LNPC), real exchange rate (LNEX), export (LNEXP) and import (LNIMP) are the additional determinants of the manufacturing value added (it is expected that the other determinants will also have considerable influence on manufacturing output). All the data used in this study are collected from the World Development Indicators (World Bank, 2018) except energy. The energy data has been collected from International Energy Statistics. All variables are expressed in Million USD (at constant 2010 US Dollars) except exchange rate and electricity consumption. Exchange rate is expressed in domestic currency per unit of USD and electricity consumption data is expressed in terms of Billion Kwh. In a single country research, converting variables into per capita term, reduces the size of the variable (Soytas et al., 2001), also Friedl and Getzner (2003) guided the use of variable in absolute terms instead of per capita term. Therefore, data in absolute terms but not per capita terms is used in this study. All these variables are converted into natural logarithm for consistent and reliable empirical results (Shahbaz et al., 2016). The functional relationship between manufacturing value added and all other variables is stated as follows:

$$LNMVA = f(LNELEC, LNPC, LNEXP, LNEX, LNIMP)$$

Before executing the time series model, it is mandatory to check the nature of the data series (Ewing et al., 2007). Hence, we examined the stationary condition of all variables using Augmented Dickey-Fuller (ADF, 1979), and Phillips-Perron (PP, 1988) tests[2]. As few variables are *I(0)* and remaining are *I(1)*, the result directed us to go for ARDL bound test (Pesaran et al., 2001). The ARDL model has certain number of advantages over traditional method of testing co-integration. Firstly, this method can be applied when variables are a mixture of *I(0)* and*I(1)*. *Secondly*, we can simultaneously estimate the short-run as well as long-run relationship among variables using ARDL bound testing procedure. In addition, the ARDL model takes care of endogeneity issue by adding lags of dependent as well as independent variables in the model. The Autoregressive distributed lag (ARDL) model is written as:

$$LNMVA_t = \alpha + \sum_{i=1}^{n_1} \gamma LNMVA_{t-i} + \sum_{i=0}^{n_2} \beta_1 LNELEC_{t-i} + \sum_{i=0}^{n_3} \beta_2 LNPC_{t-i} + \sum_{i=0}^{n_4} \beta_3 LNEX_{t-i} + \sum_{i=0}^{n_5} \beta_4 LNEXP_{t-i} + \sum_{i=0}^{n_6} \beta_5 LNIMP_{t-i} + \varepsilon_t \quad (1)$$

Where, LNMVA, LNELEC, LNPC, LNEX, LNEXP and LNIMP are variables of the study and ε_t white noise term. The bound test can be implemented by converting the Eq. (1), into a bound testing equation by including both short-run and long-run dynamics. The bound testing approach to co-integration warrants us to carry out F-test on the selected ARDL bound testing equation with appropriate lag lengths. We enforced a mandate of maximum 3 lags on the level of variables and then the optimal lag length has been chosen based on Akaike Information Criterion (AIC)[3]. The existence of co-integration is confirmed by standard F test (Pesaran et al., 2001) which has come-up with two sets of critical values (i.e. lower and upper) for bound test. The lower and upper critical values encompass the assumptions of all variables being *I(0)* and *I(1)* respectively. This provides a bound restriction encompassing all possible classifications of the variables. If the generated F-statistics from the bound testing equation lies above the upper bound, the null hypothesis of no co-integration is rejected, if it lies below the lower bound, the test fails to reject null hypothesis. However, the result is inconclusive, if the value of F statistics lies in between the lower and upper bound. Once the long-run relationship is confirmed, we can capture the short-run dynamics by converting Eq. (1) into an error correction specification (ECM) as follows:

[1] Libio Romano and Fabrizio Trau (2017).

[2] Results for ADF and PP unit root test are reported in Supplementary file 2: Table A2.

[3] We have used AIC criteria to select the maximum lag length.

$$\Delta LNMVA_t = \alpha + \sum_{i=1}^{n_1} \gamma \Delta LNMVA_{t-i} + \sum_{i=0}^{n_2} \beta_1 \Delta LNELEC_{t-i} + \sum_{i=0}^{n_3} \beta_2 \Delta LNPC_{t-i} + \sum_{i=0}^{n_4} \beta_3 \Delta LNEX_{t-i} + \sum_{i=0}^{n_5} \beta_4 \Delta LNEXP_{t-i} + \sum_{i=0}^{n_6} \beta_5 \Delta LNIMP_{t-i} + \delta EC_{t-1} + \varepsilon_t \quad (2)$$

Where δ captures the speed of adjustment, EC_{t-1} represents disequilibrium and Δ denotes first difference. The error correction coefficient indicates the speed of re-adjustment to the long-run equilibrium after short-run shocks lead to disequilibrium, and in this process, the causality is portrayed by negative and statistically significant value of the error correction term coefficient δ (Shahbaz et al., 2013).

Model diagnostic checking is very significant in the sense that some important ARDL assumptions like errors are serially independent and normally distributed. So, to check serial independence, Breush-Godfrey serial correlation LM test is used and for normality testing, Jarque-Bera test is applied. While, ARCH test is used to check the issue of heteroskedasticity in the model, and Ramsey Reset test is applied to check whether there is any misspecification in the model. Recursive CUSUM and CUSUM of squares (Brown et al., 1975) and Pesaran and Pesaran (1997) are used to detect whether any autoregressive structure is crept into the model. These tests are also used to ensure the parameter stability of the model.

Inconsiderate to the state that whether the variables are *I(0)* or *I(1)*, the ARDL bound estimation will divulge the existence of the linear relationship among the non-stationary or mixed form of variables, but this test does not reveal the direction of the relationship among the considered variables. Hence, in order to understand the cause and effect direction among those variables in general, and with special reference to the relation between electricity consumption and manufacturing output, this study employed Modified Wald test (MWALD) as suggested by Toda and Yamamoto (1995). The MWALD test emerged as a major improvement over the traditional Granger causality test as the latter test failed to consider the possibility of a non-stationarity or any cointegrating relationship, if at all, among the variables (Wolde-Rufael, 2005). The Toda and Yamamoto (1995) exercise applies a standard VAR model while variables are in levels rather than first differences (unlike Granger causality test) implying that the risk of wrongly identifying the order of integration of the series is minimized (Mavrotas and Kelly, 2001).

3. Results & discussion

The late industrialized countries are declared as ‘industrialized’ recently and they are yet to attain the characteristics of the “early and newly industrialized” countries. They are subjected to both supply and demand shocks from the international as well as from the domestic interface. Supply shocks can be external, such as price shocks through exchange rate, technological spillover through imports, and energy access through electricity. While, demand shock comes through export as its foreign component and through domestic consumption. These factors are supposed to have an impact on the production and productivity of industrial output, in late industrialized countries, which is subjected to a detailed analysis in this paper. Descriptive statistics are shown in Supplementary file 1: Table A1. The result of ADF and PP unit root tests are presented in Supplementary file 2: Table A2. Both tests demonstrate that some series are stationary at level or at first difference, or the series contains unit root. In conclusion, all series are mix of *I(0)* and *I(1)*. The condition of the data series permitted us to estimate ARDL model.

The conventional unit root tests don't include the knowledge of structural shocks and they are prone to yield biased results. So, the deficiency of ability in hitherto unit root tests in processing the information of structural breaks led to the evolution of Zivot and Andrews unit root test (1992). The Zivot and Andrews structural break unit root test has been incorporated in the analysis and the results of the test is presented in Supplementary file 3: Table A3. The specialty of Zivot and Andrews model is that it detects the presence of one single major break in the data series Mallick et al. (2018). The conventional structural break tests such as Chow (1960) test determine breaks exogenously and this may lead to an over rejection of unit root hypothesis. In this context, the Zivot and Andrews (1992) argue, that the break dates should be determined endogenously as it is correlated with data series (Narayan, 2005).

Its methodology involves a testing procedure where the time of the structural break is endogenously estimated, even the shocks are exogenous. In addition to finding structural break in the data series, the present exercise offers result similar to that of Phillips and Perron (1988) and Augmented Dickey Fuller tests (1979). From the estimated result it's found that the structural breaks vary widely across the studied nations over the periods. These structural breaks may be attributed to global as well as domestic shocks which can be generally known as Asian financial crisis in 1997 (Haque and Kim, 2002), global financial crisis in 2007–2008 (Kotz, 2009), open door system (Panagariya, 2006 & Balakrishnan, 2009) introduced in most of the developing and late industrialized nations around 2007–08, economic spillovers and cycles (IMF, 2007) experienced by the business world around 2007 and transition in the demographic structure of the globe in 2004.

3.1. Bound test result

The F-statistics for co-integration analysis based on the selected ARDL models are reported in Table 1 for all countries. All the reported F- statistics lies above the upper bound, hence the null hypothesis of no co-integration is rejected and the precondition for co-integration is established in all ten countries.

3.2. Short run estimates

The Table 2 indicates short-run implications. While MNVA is found to have a lagged impact on itself in the case of Cameroon, India, and Kenya, whereas in the case of other countries there is no such experience. Per capita income influences MNVA positively and which is statistically significant in all countries, except Tunisia. Electricity consumption has got positive and statistically significant instantaneous and lagged impact on Sri Lanka, India, Kenya while in Bangladesh and Bolivia the effect is found to be negative. Exchange rate has got positive and statistically significant instantaneous and lagged impact on MNVA in all countries except Philippines, Bangladesh and Bolivia, but in Morocco, Cameroon, Sri Lanka and Kenya, negative lag impact is also found to be statistically significant. Import is found to have a negative relationship with MNVA in Morocco, Bolivia, Cameroon and Kenya, whereas the relation is found to be positive and statistically significant only in Sri Lanka and Bangladesh. Export has got instant and lagged positive and statistically significant impact in Morocco, Tunisia, Cameroon and Peru, whereas in Sri Lanka and Bangladesh it is found to be negative and statistically significant. Error correction term is negative and statistically significant at 1% level in the case of all the countries.

3.3. Long run elasticity

The study is mainly centered on explaining the long-run relationship between electricity consumption and industrial output. The long-run

Table 1
Bound test result.

Country	**Morocco**	**Philippines**	**Sri Lanka**	**Tunisia**	**Bangladesh**
F Statistics	14.08***	5.38***	12.34***	5.29***	6.28***
Country	**Bolivia**	**Cameroon**	**India**	**Kenya**	**Peru**
F Statistics	8.90***	4.73***	23.99***	14.08***	5.37***

*** denotes statistically significant at 1% level.

Table 2
Short run estimates.

Morocco variables	Lags 0	1	2
$\Delta LNMVA$	-	-0.24 (0.18)	-
$\Delta LNPC$	0.18 (0.28)	0.60** (0.02)	0.82*** (0.00)
$\Delta LNELEC$	0.03 (0.62)	-	-
$\Delta LNEX$	0.01* (0.10)	-0.05* (0.10)	0.01 (0.99)
$\Delta LNIMP$	0.01 (0.71)	-0.09** (0.03)	-0.07* (0.08)
$\Delta LNEXP$	0.64*** (0.00)	-	-
ECM_{t-1}	-1.97*** (0.00)		

Philippines Variables	Lags 0	1	2
$\Delta LNMVA$	-	-	-
$\Delta LNPC$	0.77*** (0.00)	-	-
$\Delta LNELEC$	-0.01 (0.89)	-	-
$\Delta LNEX$	0.01 (0.95)	-	-
$\Delta LNIMP$	0.01 (0.93)	-	-
$\Delta LNEXP$	0.01 (0.97)	-0.01 (0.71)	-
ECM_{t-1}	-1.73*** (0.00)		

Sri Lanka variables	Lags 0	1	2	3
$\Delta LNMVA$	-	-	-	-
$\Delta LNPC$	0.74*** (0.00)	-	-	-
$\Delta LNELEC$	0.35*** (0.00)	-0.18* (0.09)	-.28*** (0.00)	0.16* (0.06)
$\Delta LNEX$	0.11 (0.22)	-0.14* (0.09)	-	-
$\Delta LNIMP$	-0.09 (0.25)	0.23** (0.02)	0.18** (0.02)	0.19** (0.03)
$\Delta LNEXP$	0.05 (0.25)	-.20*** (0.00)	-.13*** (0.01)	-0.13*** (0.01)
ECM_{t-1}	-0.91*** (0.00)			

Tunisia variables	Lags 0	1	2	3
$\Delta LNMVA$	-	-.15 (0.56)	0.08 (0.70)	0.09 (0.57)
$\Delta LNPC$	0.20 (0.64)	-0.45 (0.30)	-	-
$\Delta LNELEC$	0.08 (0.83)	-	-	-
$\Delta LNEX$	0.57*** (0.00)	-0.13 (0.60)	0.52** (0.03)	-
$\Delta LNIMP$	0.07 (0.54)	-	-	-
$\Delta LNEXP$	0.26** (0.02)	-.12 (0.41)	0.34*** (0.00)	-
ECM_{t-1}	-2.16*** (0.00)			

Bangladesh variables	Lags 0	1	2
$\Delta LNMVA$	-	0.02 (0.93)	-.08 (0.75)
$\Delta LNPC$	1.14** (0.04)	-0.05 (0.56)	0.98 (0.26)
$\Delta LNELEC$	-0.07 (0.32)	-0.13* (0.10)	-
$\Delta LNEX$	0.02 (0.79)	-	-
$\Delta LNIMP$	0.08* (0.07)	0.03 (0.85)	0.02 (0.36)
$\Delta LNEXP$	-0.04 (0.20)	-0.10** (0.05)	-0.11* (0.10)
ECM_{t-1}	-0.96** (0.03)		

Bolivia Variables	Lags 0	1	2
$\Delta LNMVA$	-	0.10*** (0.47)	-
$\Delta LNPC$	1.41*** (0.00)	-	-
$\Delta LNELEC$	0.08 (0.35)	-	-
$\Delta LNEX$	-0.01 (0.65)	-	-
$\Delta LNIMP$	-0.19*** (0.00)	-	-
$\Delta LNEXP$	0.01* (0.29)	-	-
ECM_{t-1}	-0.55*** (0.00)		

Cameroon variables	Lags 0	1
$\Delta LNMVA$	-	0.30*** (0.01)
$\Delta LNPC$	0.42*** (0.00)	-
$\Delta LNELEC$	-0.31** (0.04)	-
$\Delta LNEX$	0.17** (0.05)	-
$\Delta LNIMP$	-0.21** (0.04)	-
$\Delta LNEXP$	0.10* (0.08)	-
ECM_{t-1}	-0.38*** (0.00)	

India variables	Lags 0	1	2
$\Delta LNMVA$	-	1.24*** (0.00)	1.51*** (0.00)
$\Delta LNPC$	1.57*** (0.00)	-0.09 (0.76)	0.40 (0.14)
$\Delta LNELEC$	0.41** (0.03)	-0.30 (0.16)	-
$\Delta LNEX$	0.17** (0.04)	-0.17 (0.22)	0.35*** (0.01)
$\Delta LNIMP$	0.01 (0.95)	-0.11 (0.21)	-0.01 (0.96)
$\Delta LNEXP$	-0.07 (0.21)	0.03 (0.55)	0.09 (0.24)
ECM_{t-1}	-2.65*** (0.00)		

Kenya Variables	Lags 0	1	2
$\Delta LNMVA$	-	-0.72*** (0.00)	-
$\Delta LNPC$	0.18 (0.43)	0.59** (0.04)	0.81*** (0.00)
$\Delta LNELEC$	0.52*** (0.00)	-	-
$\Delta LNEX$	0.01 (0.98)	0.04* (0.08)	0.03 (0.33)
$\Delta LNIMP$	0.01 (0.91)	-0.09** (0.04)	-0.07* (0.07)
$\Delta LNEXP$	-0.02 (0.60)	-	-
ECM_{t-1}	-0.32*** (0.00)		

Peru variables	Lags 0	1	2
$\Delta LNMVA$	-	-0.02 (0.85)	-
$\Delta LNPC$	0.35*** (0.00)	0.09 (0.65)	-
$\Delta LNELEC$	0.00 (0.97)	-	-
$\Delta LNEX$	0.01 (0.15)	-	-
$\Delta LNIMP$	9.11*** (0.00)	-	-
$\Delta LNEXP$	0.13*** (0.00)	-	-
ECM_{t-1}	-1.66*** (0.00)		

***, ** and * denotes significant at 1%, 5% and 10% level respectively, and the value in parenthesis is p-value.

elasticity of all independent variables with respect to dependent variable is shown in Table 3. Countries such as India, Morocco, Sri Lanka, Bolivia, Tunisia and Kenya have got statistically significant and positive relationship between electricity consumption and manufacturing value added. India is one of the fast-growing economies in terms of growth, and other countries are also more or less marching towards sustainable growth. Hence, they demand a lot of energy requirements and their growth is led by capital intensive industrial sectors like, Petro-chemicals, petroleum products, iron and steel. And also, India is shifting from fossil fuel-based technology to electricity-based source as it is a clean energy source. As countries such as Bangladesh, Cameroon, Philippines are agrarian in nature and the structural transformation is yet to be attained,

Table 3
Long run Estimates Dependent variable LNMVA.

Country	Variables					
	C	*LNPC*	*LNELEC*	*LNEX*	*LNIMP*	*LNEXP*
Morocco	6.01*** (0.00)	-0.21* (0.07)	0.12*** (0.01)	-1.28*** (0.00)	-0.03* (0.07)	6.58*** (0.00)
Philippines	4.68*** (0.00)	0.44*** (0.00)	0.01 (0.89)	0.01 (0.95)	0.00 (0.89)	0.11*** (0.00)
Sri Lanka	35.90*** (0.00)	0.46*** (0.00)	1.05*** (0.00)	-0.04 (0.55)	-0.96*** (0.00)	0.44*** (0.00)
Tunisia	9.28*** (0.00)	0.53*** (0.00)	0.16* (0.07)	0.55*** (0.00)	0.03 (0.53)	-0.14*** (0.00)
Bangladesh	15.72*** (0.00)	0.88*** (0.00)	0.08 (0.55)	0.17 (0.34)	-0.06 (0.25)	0.27*** (0.00)
Bolivia	23.10*** (0.00)	0.49* (0.06)	0.68*** (0.00)	0.01 (0.25)	-0.29** (0.03)	0.02 (0.27)
Cameroon	6.48 (0.17)	1.10*** (0.00)	-0.08 (0.79)	-0.05 (0.84)	0.26 (0.24)	0.27 (0.11)
India	14.11*** (0.00)	0.81*** (0.00)	0.28*** (0.00)	0.03 (0.20)	0.21*** (0.00)	-0.10 (0.18)
Kenya	36.93*** (0.00)	-1.34 (0.18)	0.99** (0.02)	-0.18 (0.37)	-0.25** (0.05)	-0.28 (0.25)
Peru	0.51 (0.59)	0.41*** (0.00)	0.01 (0.97)	0.01 (0.15)	5.48*** (0.00)	0.08*** (0.00)

***, ** and * denotes significant at 1% level, 5% level and 10 % level respectively. The value in parenthesis is p-value.

their electricity consumption for manufacturing activities is very limited, according to the results attained by the empirical analysis. Electricity may not be used for industrial production efficiently and is redirected for some other purposes in those nations.

From the empirical analysis, it is found that the coefficient of import is statistically significant indicating that import is the major source of technological transfer to countries such as, India and Peru, while the coefficient is negative for Morocco, Sri Lanka and Bolivia. Except Tunisia and Morocco, in no other country exchange rate is playing a key role in industrial output. The coefficient is positive in Tunisia while it's negative in Morocco. This probably indicates the repercussions of exchange rate shocks, which crept into the manufacturing output of each country in different terms. In addition, export has proved to have statistically significant influence on LNMVA in Morocco, Philippines, Sri Lanka, Tunisia and Bangladesh. This shows that the export arena, as far as industrial output is concerned, has been ruled by industrialized nations and the late industrialized countries are having less share of foreign market as far as their industrial output is concerned.

3.4. Diagnostic test

The diagnostic statistics for all individual ARDL models are presented in Table 4. The Ramsey RESET test results indicate that the models do not suffer from misspecification problem. Lagrange multiplier (LM) tests that reveal there is no serial correlation at 5% significance level, JB test results show that all residuals are normally distributed. Further, ARCH test shows that there is no heteroscedasticity problem in our models.

3.5. Stability of the model

To check the robustness of models, the structural stability test of the parameter on the axis cumulative sum of recursive residuals (CUSUM) and cumulative sum of recursive residuals squares (CUSUMSQ) approaches propounded by Pesaran and Pesaran (1997), are applied. The graphical representation of CUSUM and CUSUMSQ are given in Fig. 1. According to the guideline, if the plots remain within the 5% level of critical bound, then it means the parameters of the models are stable and consistent. Our model plots show that the CUSUM and CUSUMSQ are within the boundaries for all countries throughout the period, except in the case of Bangladesh, India and Peru. But still, the parameters of long-run estimates converging to the zero mean in the long-run reveals that models are stable and consistent. Hence, the CUSUM and CUSUM of square tests could not verify a stability violation in any of the countries in the late industrialized category. For each country, the upper figure represents CUSUM at 5% level of significance and the lower one is CUSUMSQ at 5% level of significance.

Table 4
Diagnostic test.

Country	RESET Test	LM Test	JB Test	ARCH Test
Morocco	0.73 (0.41)	1.41 (0.29)	2.24 (0.32)	1.46 (0.23)
Philippines	0.85 (0.40)	0.31 (0.73)	0.04 (0.97)	0.60 (0.44)
Sri Lanka	1.15 (0.30)	1.46 (0.28)	0.69 (0.70)	0.01 (0.89)
Tunisia	22.13 (1.15)	0.79 (0.47)	0.07 (0.96)	0.41 (0.52)
Kenya	0.76 (0.41)	1.41 (0.29)	2.24 (0.32)	0.46 (0.23)
Bangladesh	0.13 (0.89)	1.47 (0.33)	0.16 (0.91)	1.96 (0.13)
Bolivia	1.25 (0.27)	1.91 (0.17)	0.45 (0.79)	0.17 (0.67)
Cameroon	0.89 (0.37)	0.17 (0.83)	1.43 (0.48)	0.02 (0.86)
India	1.31 (0.31)	0.78 (0.53)	0.48 (0.78)	0.60 (0.44)
Peru	1.00 (0.32)	0.45 (0.64)	0.30 (0.85)	0.14 (0.71)

Notes:
1. The value above the parenthesis is F-Statistics.
2. The value in parenthesis is p-values.
3. RESET is Ramsey model specification test to check model stability.
4. LM is Lagrange Multiplier test for serial correlation.
5. JB is Jarque-Bera normality test.
6. ARCH is Heteroskedasticity test.

3.6. Toda Yamamoto causality test

After estimating long-run results, we proceeded to causality test. From the estimation of the Toda Yamamoto Granger causality test (see Table 5.), the study attained a kaleidoscopic result, which is as follows: For Morocco, Bangladesh, Bolivia and India, there is unidirectional causality flowing from electricity consumption to industrial output thereby supporting *growth hypothesis* and for Tunisia, the reverse causality is established *supporting conservation hypothesis*. There is bidirectional causality running in the case of Peru giving testimony to *feedback hypothesis*. At the same moment, *neutrality hypothesis* is found in the case of Sri Lanka, Cameroon and Kenya. Per capita income is found to have a significant causal effect on manufacturing value added with respect to Cameroon and India. Manufacturing value added has reverse causality to per capita income in countries such as Philippines and Peru. Interestingly, import has contributed to the manufacturing value added in Sri Lanka, Cameroon, India and Peru. Manufacturing value added has unidirectional causal effect on imports for Philippines. There is bidirectional causality established between Sri Lanka and Cameroon. Export Granger causes Manufacturing value added in Bolivia, while reverse causality is found in Tunisia, Bangladesh, Kenya and Peru.

4. Discussion & conclusion

The whole study centers around analyzing the relation between manufacturing value added and electricity consumption, which is expressed in natural logarithmic form along with variables such as per capita income, exports, imports and exchange rate for ten late industrialized economies for the period 1980–2016. After employing unit root tests (Augmented Dickey Fuller and Phillip Perron), we found that the variables are a mix of *I(0)* and *I(1)*. Hence, ARDL bounds test approach of cointegration was employed followed by Toda- Yamamoto Granger causality test in order to elicit the relationship between electricity consumption and industrial output, provided the influence of other certain variables are retained. The empirical evidence is acquired from ARDL bounds followed by Toda-Yamamoto Granger causality test. The entire result is mixed in nature and can broadly be classified into four hypotheses, which are available in the existing literature such as *growth, conservation, feedback, and neutralily hypotheses.*

For countries like, Morocco, Bangladesh, Bolivia and India, there is unidirectional causality flowing from electricity consumption to manufacturing output, which testifies *growth hypothesis*. For such countries electricity reduction policy will prove fatal on industrial output. This relationship is retained in the long-run as indicated by positive and statistically significant coefficients, except Bangladesh. Hence, any energy policy, which reduces electricity consumption, will have negative impact on output both in the short-run and in the long-run. So, the electricity policy for industry should be made realizing this aspect. While, reverse causality is established in the case of Tunisia supporting *conservation hypothesis*. Thus, electricity reduction policy in the context of industrial sector may not incur any negative impact in the short-run and in the long-run.

The *feedback hypothesis* is found relevant in the case of Peru and in this context, there is a symbiotic relationship. Hence, policy suggestion in this regard is to frame a policy, which won't destabilize this symbiotic relationship. The long-run impact cannot be estimated out to be significant in this regard, which implies, there is no long-run policy implications. In the case of Sri Lanka, Cameroon and Kenya, there is *neutrality hypothesis* in regime and electricity reduction commitments and policy suggestions won't have any impact on industrial output.

Import has contributed as a major vehicle of technology transfer in the case of Sri Lanka, Cameroon, India and Peru and the policies which augments FDI cap so as to share import burden in this direction can be framed. Per capita income is found to have a cause and effect relationship with manufacturing value added in Cameroon and India, supporting domestic *demand-led growth hypothesis* and policies which augments

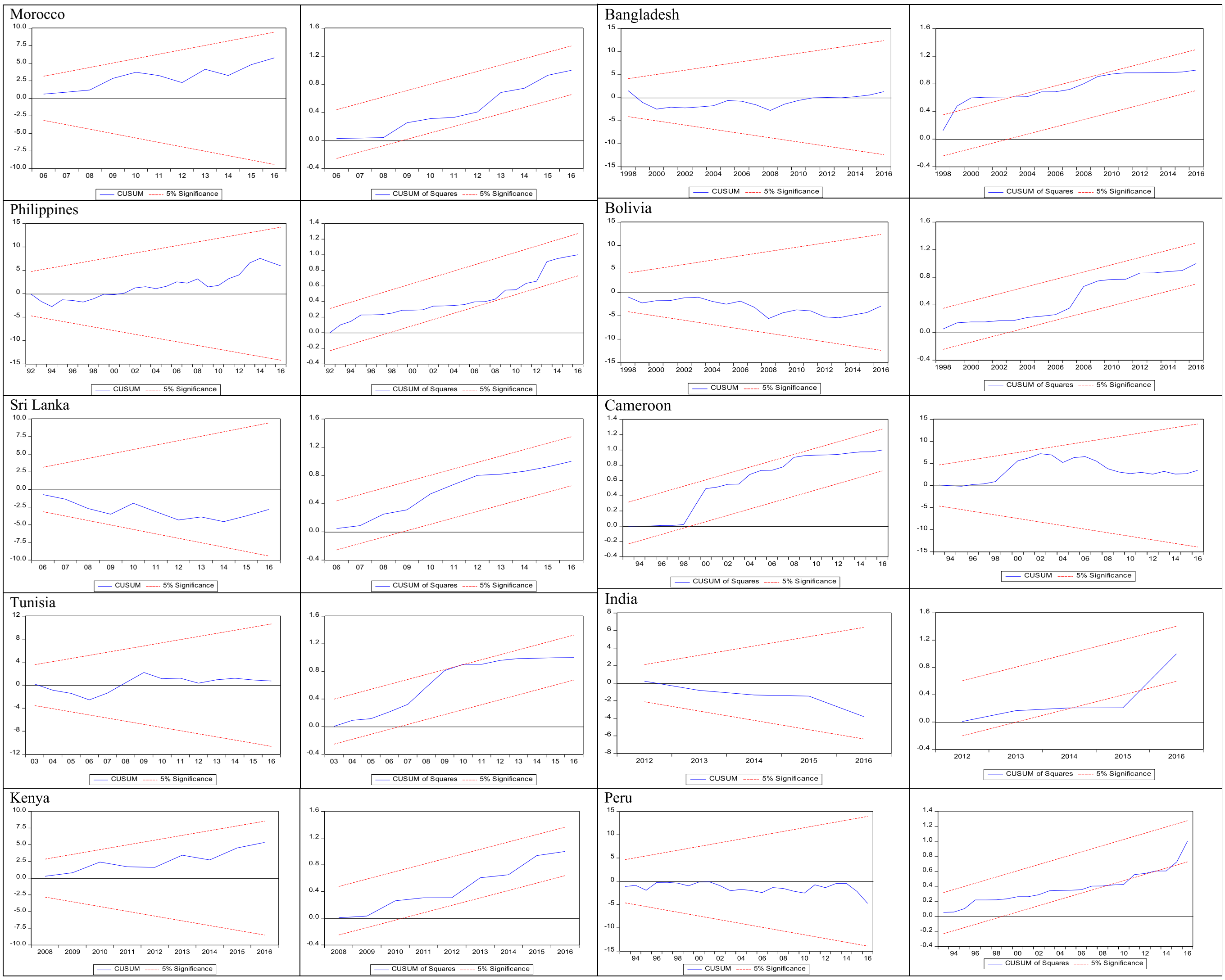

Fig. 1. CUSUM and CUSUM of square tests.

Table 5
Toda-Yamamoto causality test.

Countries			Morocco		Philippines		Sri Lanka		Tunisia		Bangladesh	
Cause	→	Effect	Test Statistics	P value	Test Statistics	P value	Test Statistics	P value	Test Statistics	P value	Test Statistics	P value
LNELEC	→	LNMVA	5.39	0.02**	2.85	0.24	4.60	0.32	1.68	0.79	11.89	0.02**
LNMVA	→	LNELEC	0.10	0.74	2.16	0.33	0.01	2.48	0.64	0.00***	2.81	0.58
LNMVA	→	LNPC	0.34	0.55	5.02	0.08*	4.24	0.37	5.04	0.28	1.26	0.86
LNPC	→	LNMVA	2.15	0.14	3.30	0.19	11.00	0.02	3.93	0.41	5.66	0.22
LNMVA	→	LNIMP	1.34	0.24	11.33	0.00***	11.81	0.01**	342.9	0.00	4.29	0.36
LNIMP	→	LNMVA	0.03	0.85	2.90	0.23	15.79	0.00***	5.75	0.21	3.68	0.45
LNMVA	→	LNEXP	0.13	0.71	0.45	0.76	4.36	0.35	19.49	0.00***	12.75	0.01***
LNEXP	→	LNMVA	0.57	0.44	0.23	0.88	7.50	0.11	3.93	0.41	2.05	0.72
LNMVA	→	LNEX	7.27	0.00***	0.45	0.76	10.90	0.02**	7.44	0.11	1.04	0.90
LNEX	→	LNMVA	0.05	0.82	0.07	0.96	5.71	0.22	3.69	0.44	7.29	0.12
			Bolivia		Cameroon		India		Kenya		Peru	
LNELEC	→	LNMVA	14.06	0.00***	1.71	0.42	3.46	0.06*	1.88	0.75	14.27	0.00***
LNMVA	→	LNELEC	4.42	0.11	0.05	0.97	0.08	0.77	3.91	0.41	10.50	0.03**
LNMVA	→	LNPC	2.43	0.29	0.30	0.83	0.23	0.62	3.76	0.43	18.48	0.00***
LNPC	→	LNMVA	1.18	0.55	7.16	0.02**	3.85	0.05**	0.94	0.91	7.37	0.11
LNMVA	→	LNIMP	4.30	0.11	8.17	0.02**	0.53	0.46	0.69	0.79	2.35	0.67
LNIMP	→	LNMVA	2.06	0.35	5.98	0.05**	5.90	0.01***	0.99	0.91	8.73	0.06*
LNMVA	→	LNEXP	4.42	0.11	1.44	0.48	0.82	0.36	11.85	0.02**	16.89	0.00***
LNEXP	→	LNMVA	16.00	0.00***	3.02	0.22	0.56	0.45	0.71	0.60	4.97	0.28
LNMVA	→	LNEX	3.32	0.18	0.75	0.68	0.16	0.68	18.04	0.00***	6.23	0.18
LNEX	→	LNMVA	3.94	0.13	0.36	0.83	0.44	0.50	1.62	0.80	4.97	0.28

***, ** and * denotes statistically significant at 1%, 5% and 10% level respectively.

domestic demand in future is a compulsory choice. Manufacturing acts as a factor augmenting per capita income in Philippines and Peru and this gives ample policy leverage to use industrial sector as a tool to transform the standard of living of the people.

Even though, they are listed in the late industrialized group, the results found are highly varying, which can be attributed to the factors such as the endowment of natural resources, size of population, level of technology, nature of labor market, functioning of governments' machinery and variety of industrial production. Also, scale of trade and nature of economic development vary widely across those nations. The above-mentioned factors influence the level of electricity consumption through industrial process.

Declarations

Author contribution statement

Arumugan Sankaran: Conceived and designed the experiments; Wrote the paper.

Sanjay Kumar: Performed the experiments; Wrote the paper.

Arjun K: Analyzed and interpreted the data; Wrote the paper.

Mousumi Das: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interest statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at https://doi.org/10.1016/j.heliyon.2019.e01904.

References

Abokyi, Eric., Konadu, A.P., Sikayena, Isaiah., Abayie, O.F. Eric, 2018. Consumption of electricity and industrial growth in the case of Ghana. Hindawi J. Energy 1–11.
Alam, 2006. Economic Growth with Energy. MPRA, Northeastern University, Boston, pp. 1–27.
Alley, Ibrahim, Egbetunde, Tajudeen, Oligbi, Blessing, 2016. Electricity supply, industrialization and economic growth: evidence from Nigeria. Int. J. Energy Sect. Manag. 10 (4), 511–525.
Altinay, G., Karagol, E., 2005. Electricity consumption and economic growth: evidence from Turkey. Energy Econ. 27 (6), 849–856.
Apergis, N., Payne, J.E., 2009. CO2 emissions, energy usage, and output in Central America. Energy Policy 37 (8), 3282–3286.
Apergis, Nicholas., Payne, E. James., 2010a. Coal consumption and economic growth: evidence from a panel of OECD countries. Energy Policy 1353–1359.
Apergis, N., Payne, J.E., 2010b. Energy consumption and growth in South America: evidence from a panel error correction model. Energy Econ. 32 (6), 1421–1426.
Asafu-Adjaye, J., 2000. The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. Energy Econ. 22 (6), 615–625.
Balakrishnan, P., 2009. Mystifying India's economic growth. Econ. Pol. Wkly. 44, 33–35.
Belke, A., Dobnik, F., Dreger, C., 2011. Energy consumption and economic growth: new insights into the cointegration relationship. Energy Econ. 33 (5), 782–789.
Bernard, A.O., Obio, Kenneth., 2016. Is energy consumption relevant to industrial output in Nigeria? Int. J. Res. Manag. Econ. Com. 06, 15–22.
Branson, H., Love, P., 1988. Misalignment of Exchange Rates: Effects on Trade and Industry. University of Chicago Press, pp. 241–276.
Brown, R.L., Durbin, J., Evans, J.M., 1975. Techniques for testing the constancy of regression relationships over time. J. R. Stat. Soc. Ser. B 37 (2), 149–163.
Chang, C.C., 2010. A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Appl. Energy 87 (11), 3533–3537.
Chebbi, H.E., Boujelbene, Y., 2008. CO2 Emissions, Energy Consumption and Economic Growth in Tunisia (No. 725-2016-49474).
Cheng, B.S., 1997. Energy consumption and economic growth in Brazil, Mexico and Venezuela: a time series analysis. Appl. Econ. Lett. 4 (11), 671–674.
Chiou-Wei, S.Z., Chen, Ching Fu., Zhu, Z., 2008. Economic growth and energy consumption revisited—evidence from linear and nonlinear Granger causality. Energy Econ. 30 (6), 3063–3076.
Chow, G.C., 1960. Tests of equality between sets of coefficients in two linear regressions. Econometrica J. Econ. Soc. 591–605.
Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. J. Am. Stat. Assoc. 74 (366a), 427–431.
Eaton, J., Kortum, S., 2002. Technology, geography, and trade. Econometrica 70 (5), 1741–1779.
Ekholm, K., Moxnes, A., Ulltveit-Moe, K.H., 2012. Manufacturing restructuring and the role of real exchange rate shocks. J. Int. Econ. 86 (1), 101–117.
Ewing, B.T., Sari, R., Soytas, U., 2007. Disaggregate energy consumption and industrial output in the United States. Energy Policy 35 (2), 1274–1281.
Friedl, B., Getzner, M., 2003. Determinants of CO2 emissions in a small open economy. Ecol. Econ. 45 (1), 133–148.
Ghali, K.H., El-Sakka, M.I.T., 2004. Energy use and output growth in Canada: a multivariate co integration analysis. Energy Econ. 26, 225–238.
Glasure, Y.U., 2002. Energy and national income in Korea: further evidence on the role of omitted variables. Energy Econ. 24, 355–365.
Haque, M., Kim, S.H., 2002. The Asian financial crisis of 1997: causes and policy responses. Multinatl. Bus. Rev. 10, 37–44.
Hassan, Danmaraya, 2016. Electricity consumption and manufacturing sector productivity in Nigeria: an autoregressive distributed lag-bounds testing approach. Int. J. Energy Econ. Policy 6 (2), 195–201.
Hondroyiannis, G., Lolo, S., Papapetrou, E., 2002. Energy consumption and Economic growth: assessing the evidence from Greece. Energy Econ. 24 (4), 319–336.
IAEA, 2009. IAEA Tools and Methodologies for Energy System Planning and Nuclear Energy System Assessments. International Atomic Energy Agency, Austria.
International Monetary Fund, 2007. World Development Outlook. Washington D.C, United States.
Iyke, B.N., 2015. Electricity consumption and economic growth in Nigeria: a revisit of the energy growth debate. Energy Econ. 51, 166–176.
Karumba, Mary, 2012. The Relationship between Electricity Consumption and Output in Kenya's Manufacturing Sector, p. 129. KIPPRA Discussion Paper.
Khan, M.A., Qayyum, A., 2007. Dynamic Modeling of Energy and Growth in South Asia||.
Kotz, D.M., 2009. The financial and economic crisis of 2008: a systemic crisis of neoliberal capitalism. Rev. Radic. Polit. Econ. 41 (3), 305–317.
Kraft, J., Kraft, A., 1978. On the relationship between energy and GNP. J. Energy Dev. 401–403.
Kumar, V., Kumar, U., Persaud, A., 1999. Building technological capability through importing technology: the case of Indonesian manufacturing industry. J. Technol. Transf. 24 (1), 81–96.
Lau, E., Chye, X.H., Choong, C.K., 2011. Energy-growth causality: Asian countries revisited. Int. J. Energy Econ. Policy 1 (4), 140–149.
Lee, C.C., Chang, C.P., 2008. Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. Resour. Energy Econ. 30 (1), 50–65.
Liu, X., Buck, T., 2007. Innovation performance and channels for international technology spillovers: evidence from Chinese high-tech industries. Res. Pol. 36 (3), 355–366.
Magazzino, C., 2015. Economic growth, CO2 emissions and energy use in Israel. Int. J. Sustain. Dev. World Ecol. 22 (1), 89–97.
Mallick, H., Mahalik, M.K., Sahoo, M., 2018. Is crude oil price detrimental to domestic private investment for an emerging economy? The role of public sector investment and financial sector development in an era of globalization. Energy Econ. 69, 307–324.
Mavrotas, G., Kelly, R., 2001. Old wine in new bottles: testing causality between savings and growth. Manch. Sch. 69, 97–105.
Mawejje, Joseph., Mawejje, Dorothy N., 2016. Electricity consumption and sect oral output in Uganda: an empirical investigation. J. Econ. Struct. The Official Journal of the Pan-Pacific Association of Input-Output Studies (PAPAIOS), 20165:21.
Mohammad, H., Parvaresh, H., 2014. Energy consumption and output: evidence from a panel of 14 oil-exporting countries. Energy Econ. 41, 4–46.
Narayan, P.K., 2005. The saving and investment nexus for China: evidence from cointegration tests. Appl. Econ. 37 (17), 1979–1990.
Narayan, P.K., Smyth, R., 2008. Energy consumption and real GDP in G7 countries: new evidence from panel co integration with structural breaks. Energy Econ. 30, 2331–2341.
Odhiambo, N.M., 2009. Energy consumption and economic growth nexus in Tanzania: an ARDL bounds testing approach. Energy Policy 37 (2), 617–622.
Olufemi, J Ogunjobi, 2015. The effects of electricity consumption on industrial growth in Nigeria. J. Econ. Sustain. Dev. 6, 54–59.
Panagariya, A., 2006 October. Transforming India. In: Conference on India: An Emerging Giant. Columbia University.
Parker, Steven., Liddle, Brantley., 2016. Energy efficiency in the manufacturing sector of the OECD: analysis of price elasticities. Energy Econ. 38–45.
Pastén, R., Saens, R., Contreras Marin, R., 2015. Does energy use cause economic growth in Latin America? Appl. Econ. Lett. 22 (17), 1399–1403.
Patrick, Enu, 2014. Sectoral estimation of the impact of electricity consumption on real output in Ghana. Int. J. Econ. Com. Manag. 2 (9).
Pesaran, M.H., Pesaran, B., 1997. Microfit 4.0, an Interactive Economics Analysis. Oxford University Press, 1997.

Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. J. Appl. Econom. 16 (3), 289–326.
Phillips, P.C., Perron, P., 1988. Testing for a unit root in time series regression. Biometrika 75 (2), 335–346.
Polemis, 2007. Modeling industrial energy demand in Greece using co integration techniques. Energy Policy 35, 4039–4050.
Rahman, A., Amin, S., 2011. Energy-growth nexus in Bangladesh: an empirical study. Int. Rev. Bus. Res. Pap. 7 (2), 182–195.
Romano, L., Traù, F., 2017. The nature of industrial development and the speed of structural change. Struct. Change Econ. Dynam. 42, 26–37.
Sami, Janesh, 2012. Sectoral electricity consumption and economic growth in Philippines: new evidence from Co integration and causality results. In: FNU College of Business, Hospitality &Tourism Studies, Working Paper Series, pp. 03–12.
Sari, R., Ewing, B.T., Soytas, U., 2008. The relationship between disaggregate energy consumption and industrial production in the United States: an ARDL approach. Energy Econ. 30 (5), 2302–2313.
Shahbaz, M., Hye, Q.M.A., Tiwari, A.K., Leitão, N.C., 2013. Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Renew. Sustain. Energy Rev. 25, 109–121.
Shahbaz, M., Loganathan, N., Muzaffar, A.T., Ahmed, K., Jabran, M.A., 2016. How urbanization affects CO2 emissions in Malaysia? The application of STIRPAT model. Renew. Sustain. Energy Rev. 57, 83–93.
Shiu, A., Lam, P.L., 2004. Electricity consumption and economic growth in China. Energy Policy 32 (1), 47–54.
Siddiqui, R., 2004. Energy and economic growth in Pakistan. Pakistan Dev. Rev. 43 (2), 175–200.
Soytas, U., Sari, R., Özdemir, O., 2001. Energy consumption and GDP relation in Turkey: a Co integration and vector error correction analysis. In: Economies and Business in Transition: Facilitating Competitiveness and Change in the Global Environment Proceedings. Global Business and Technology Association, pp. 838–844.
Stern, D.I., 2000. Multivariate co integration analysis of the role of energy in the US macro economy. Energy Econ. 22 (2), 267–283.
Tapsın, Gulcin, 2017. The link between industry value added and electricity consumption. Eur. Sci. J. 13, 41–56.
Toda, H.Y., Yamamoto, T., 1995. Statistical inference in vector autoregressions with possibly integrated processes. J. Econom. 66 (1-2), 225–250.
Velasquez, J.R.C., Pichler, B., 2010. China's increasing economy and the impacts on its energy. Estud. Gerenciales 26 (117), 131–143.
Wang, Y., Wang, Y., Zhou, J., Zhu, X., Lu, G., 2011. Energy consumption and economic growth in China: a multivariate causality test. Energy Policy 39, 4399–4406.
Wolde-Rufael, Y., 2004. Disaggregated industrial energy consumption and GDP: the case of Shanghai. Energy Econ. 26, 69–75.
Wolde-Rufael, Y., 2005. Energy demand and economic growth: the African experience. J. Policy Model. 27 (8), 891–903.
Wolde-Rufael, Y., 2006. Electricity consumption and economic growth: a time series experiment for 17 african countries. Energy Policy 34, 1106–1114.
Yang, Z., Zhao, Y., 2014. Energy consumption, carbon emissions, and economic growth in India: evidence from directed acyclic graphs. Econ. Modell. 38, 533–540.
Yew Wah, L., 2004. The role of domestic demand in the economic growth of Malaysia: a cointegration analysis. Int. Econ. J. 18 (3), 337–352.
Yu, E.S., Choi, J.Y., 1985. The causal relationship between energy and GNP: an international comparison. J. Energy Dev. 10 (2), 249–272.
Yuan, J., Zhao, C., Yu, D., Hu, Z., 2007. Electricity consumption and economic growth in China, Co integration and Co-feature analysis. Energy Econ. 29, 1179–1191.
Zivot, E., Andrews, D.W.K., 1992. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. J. Bus. Econ. Stat. 20 (1), 25–44.