European Online Journal of Natural and Social Sciences 2018; www.european-science.com
Vol.7, No 2 pp. 407-423
ISSN 1805-3602

The relationship between industrial electricity consumptions, industrial employment and industrial GDP

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Received for publication: 05 January 2018.
Accepted for publication: 01 March 2018.

Abstract

The study was carried out to see how electricity affects industry by identifying the relationship between industrial electricity consumptions, industrial employment and industrial GDP. Industrial electricity shortage has been a major threat and has caused approximately two percent loss to the Pakistan's economy with rate of unemployment reaching 6% during 2013-14, leaving millions unemployed across the country. Co-integration and granger causality test was employed to find long-term relationship between industrial electricity consumption, employment and industrial growth. Results revealed that all three; industrial electricity consumption, employment and industrial growth, were stationarity at 1st difference and co-integrated on the basis of optimal lag selection criteria. Vector error correction model employed to test the speed of adjustment showed that industrial GDP & industrial electricity, and industrial employment & industrial GDP, both were significant at 5% level, while Industrial employment and industrial electricity was significant at 13.5%. Results of granger causality indicated that industrial electricity has a long-term relationship both with industrial GDP and industrial employment. Data analysis revealed that for Pakistan's economic growth reliable electricity to industrial sector is essential and hindrance or unavailability of electricity to industry will lead to unemployment and reduce economic growth.

Keywords: Industrial electricity, industrial employment, Industrial growth, Co-Integration, Granger Causality, Vector Error Correction Model

Introduction

Since inception, till 1800's the human population reached one billion and in next 160 years, it reached three billion. World's population stands at about 7.6 billion in the mid of 2017 with the addition of nearly one billion in the last twelve years and a projection of 9.8 billion by 2050, Asia which is projected to have a highest economic growth rate in coming years has sixty percent of world's population (United Nations, 2017). Increasing prosperity, economic growth and population growth particularly in Asia, energy demand is increasing, however, because of the need to reduce carbon imprint and technological advancements the energy mix has started to shift from oil-based to renewables (British Petroleum, 2017). The world energy consumption and percent share are shown in Figures 1 and 2.

Population, economic activity, and technology are the main drivers that create the demand for energy particularly electricity, which is considered to be the cleanest. Energy is used in many ways every day, these needs are expected to grow particularly in developing nations where urbanization and increase in income will demand more electricity and other forms of energy not only at home but also production and provision of goods and services to fulfill this growing demand will put pressure on the energy sources. The biggest growth is for electricity, which we expect to be available 24/7/365 to keep our industry running and power our homes, accounting for 40% of all energy used in the world by 2040, furthermore, world industry accounts for 50% of electricity demand and industrial energy usage is expected to grow by 30% by 2040 (ExxonMobil, 2016). 35% of global energy use is from power generation which will continue to grow as the technologies evolve, products and services expectations increase, people gain access to electricity, with 65% expected rise in electricity demand by 2040 and out of this increase in demand 85% will come from developing nations (ExxonMobil, 2016). Numerous reports from World Bank, International Monetary Fund, ExxonMobil, United Nations and others highlighted the significant increase in the demand for electricity, especially in the developing and underdeveloped countries.

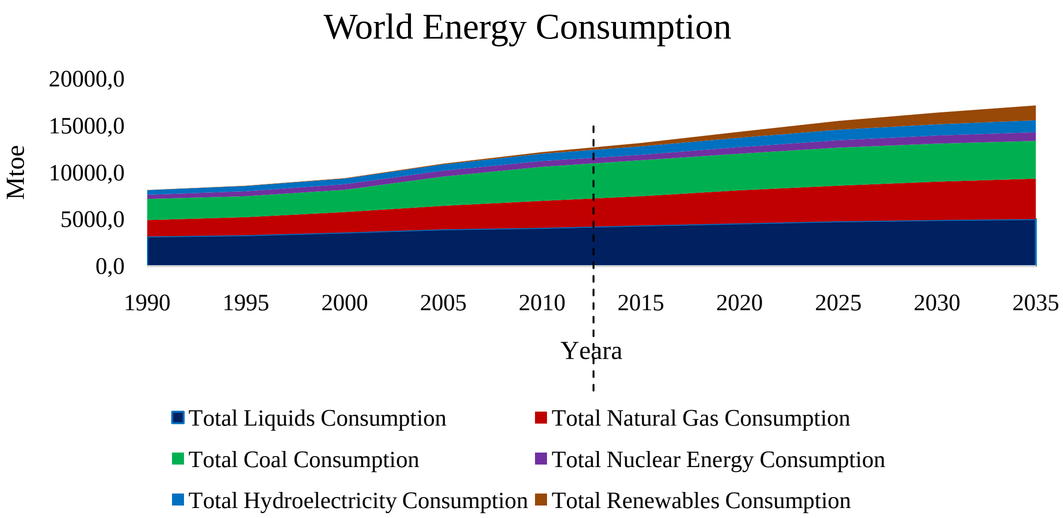

Figure 1. World energy consumption, British Petroleum, 2017

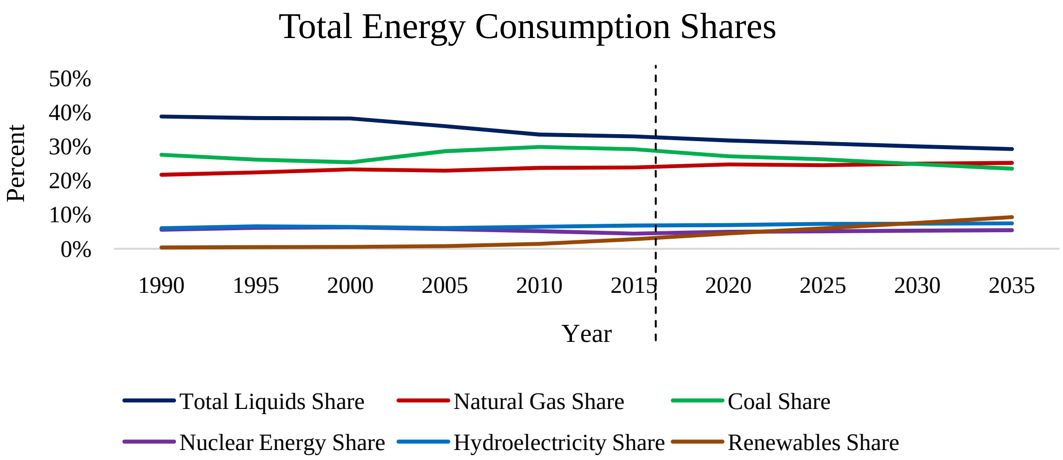

Figure 2. Total energy consumption shares, British Petroleum, 2017

Energy is not only necessary for economic growth and development but also to enhance the standard of living by providing employment. Increase in population is straining energy resources particularly in developing countries with increasing affluence. Asia accounts for about 60% of world population with China and India contributing about 19% and 18% respectively (United Nations, 2017). The world economy is expected to double by 2050 with emerging economies dominating the list of ten largest economies of the world with world GDP share of almost 50% by 2050 – five of these economies namely China, India, Japan, Russia, and Indonesia are in Asia (PricewaterhouseCoopers, 2017). It is also expected that the growth of these countries will create a second tier of robust growth among their neighbors i.e. Philippines, Singapore, South Korea, Vietnam, Taiwan, Kyrgyzstan, Thailand, and Australia. What it entails is that energy consumption is going to increase in coming decades and if Pakistan is to benefit, it must reform its energy sector, especially the availability of electricity.

Since 1960 Pakistan has been unable to cater for electricity demand with the difference between maximum demand and sales increasing as shown below:

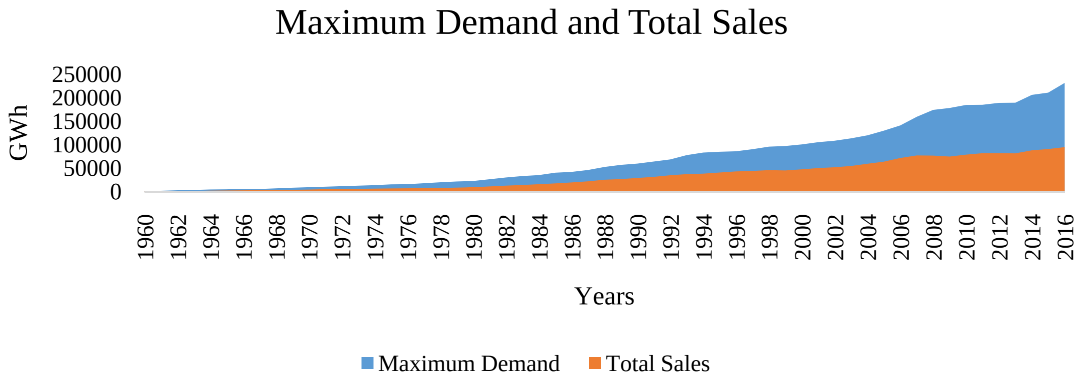

Figure 3. Maximum demand and total sales, National Transmission and Despatch Company, 2016

The shortfall was 45 MW in 1960, but 56 years later this shortfall has increased to 8000 MW in 2016 with no sign of abatement, as shown below:

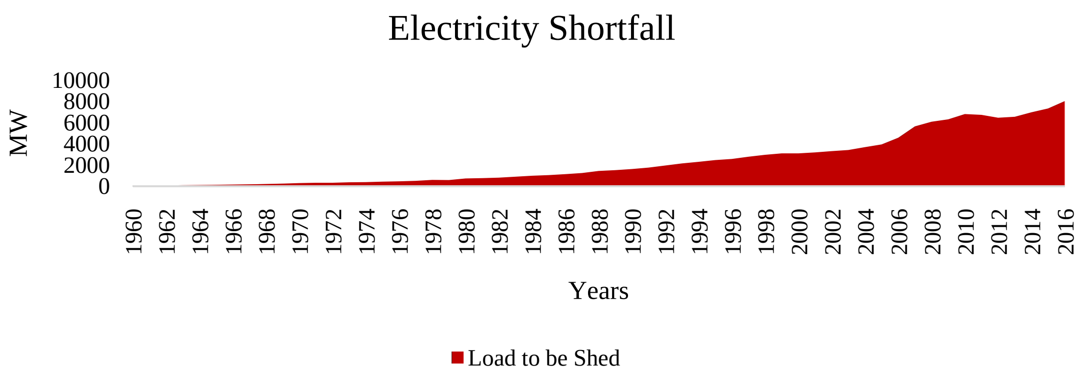

Figure 4. Electricity shortfall calculated from National Transmission and Despatch Company, 2016

Problem Statement

According to British Petroleum Asia-Pacific, energy consumption will increase by 54% and production by 46% from 2014 to 2035 (British Petroleum, 2016). According to the report of World Bank, Pakistan is placed at the eighth number in South Asia with a growth rate of 4.4 % and second lowest after Afghanistan, cautioning against energy constraints (World Bank, 2015). This shortage of energy has a severe negative impact over the socio-economic wellbeing of the country which causes almost 4% to 7% decline in the GDP of Pakistan (Ministry of Planning, Development & Reform, 2015). This shortage of energy causes two percent loss annually to the GDP of the country. The impact on revenue generation is almost Rs. 52 billion (Sustainable Development Policy Institute, 2015). Moreover, the rate of unemployment aggravated to 6% in 2013-14, leaving millions of people unemployed across the country (Ministry of Finance, 2015). Manufacturers are badly effected by power shortages as it is the most important input to the manufacturing process, unfortunately, electricity shortage in terms load shedding are commonplace in Pakistan severely affecting the electricity intensive industries like manufactures of metal, paper, and wood (Grainger & Zhang, 2017).

Research Significance

Identifying the relationship between industrial electricity consumption with industrial GDP and industrial employment and of industrial GDP with industrial employment will help policymakers to focus on relevant aspects which will help in economic growth. The study focusses on industrial sector only and to best of researcher's knowledge no study has focused on the industrial GDP, industrial employment, and industrial electricity consumption, thus a gap exists and the study aims to fulfill this gap.

Research Objectives

The following research objectives were addressed:

1. To identify the relationship between industrial GDP and industrial electricity consumption
2. To identify the relationship between industrial employment and industrial electricity consumption
3. To identify the relationship between industrial GDP and industrial employment

Research Questions

With respect to research objectives the following research questions were answered:

1. What is the relationship between industrial GDP and industrial electricity consumption?
2. What is the relationship between industrial employment and industrial electricity consumption?
3. What is the relationship between industrial GDP and industrial employment?

Research Hypothesis

The corresponding research hypo study is:

1. There is a significant relation between industrial GDP and industrial electricity consumption
2. There is a significant relation between industrial employment and industrial electricity consumption
3. There is a significant relation between industrial GDP and industrial employment

Literature Review

Relationship between Energy and Employment Generation

Understanding and developing a theoretical relationship between employment and energy consumption helps in determining the focus on determinants and devising policies that will guide the future implementations. Various aspects can be theorized to employment and energy use particularly electricity, including demographics, income, price, substitution, and technology.

Dependence of Employment on Electricity

Studies have been conducted to see the relationship between electricity and employment. For instance study of New Zealand from 1960 to 1999 showed electricity consumption and oil use positively related to employment and the relationship was bi-directional (Fatai, Oxley, & Scrimgeour, 2004). Likewise, a study of Australia during 1966 to 1999 by Narayan and Smyth (2005), also showed the long-term uni-directional positive relationship between employment and electricity consumption, with higher employment lead to higher electricity consumption. The study in India for the period of 1971 to 2006 on relationship between electricity supply, employment, and GDP, indicated that electricity was required for economic growth and thus lead to more employment, real GDP growth required more electricity consumption and lead to higher rate of employment, electricity supply and employment were found to be positively related (Ghosh, 2009). A study of Kenya from 1972 to 2006 by Odhiambo (2010) on electricity consumption, economic growth, and labor force participation, showed higher electricity consumption resulting in higher economic growth and in turn higher economic growth lead to higher employment. A study on Turkey from 2005 to 2010 between electricity consumption and employment showed a uni-directional causal relationship, with higher electricity consumption causing higher employment (Polat & Uslu, 2012). In Poland study a from 2000 to 2009 by Gurgul and Lach (2012) revealed the positive impact on employment and economic growth because of electricity consumption, economic growth is positively related to employment and employment positively impacts economic growth. In Italy a study by Magazzino (2014) for the period of 1970 to 2009 showed the positive bi-directional relationship between GDP growth and electricity demand, however, the study failed to establish any such relationship between electricity demand and employment.

Energy Consumption and Economic Growth

Kraft and Kraft (1978) perhaps started the debate between energy consumption and economic growth, and after more than three and a half decades it is far from over. No unanimous consensus as to the directional causality exists because of conflicting results. However, four views as to energy consumption and economic growth came fourth. The first view is the energy-led economic growth which states economic growth is the result of energy consumption. The second view growth-driven energy consumption is based on that economic growth leads to higher consumption of energy. Third view feedback has a bidirectional relationship that energy consumption causes economic growth and economic growth causes more energy consumption. The fourth view is neutrality as there is no relationship between energy consumption and economic growth or that such a relationship cannot be substantiated. These controversies in literature create a need to address the issue further.

Energy-led Economic Growth View

Numerous studies have confirmed the first view of energy-led, in most of the cases, energy means electricity led economic growth. Among the studies are; for India using VECM by Masih and Masih (1996); for India, and Indonesia with varying sample periods using VECM by Asafu-Adjaye (2000); for Shanghai from 1952-1999 using bivariate Toda-Yamamoto by Wolde-Rufael (2004); for Indonesia, and India, from 1960-1999 using bivariate Toda-Yamamoto by Fatai, Oxley, and Scrimgeour (2004); for New Zealand using Granger causality by Oxley, Scrimgeour, and Fatai (2004); for Sri Lanka using Yang’s regression analysis from 1954-1997 by Morimoto and Hope (2004); for Pakistan from 1971-2003 using ARDL by Siddiqui (2004); for China from 1971-2000 using Granger Causality by Shiu and Lam (2004); for eighteen developing countries from 1975-

2001 using panel cointegration by Lee (2005); for Benin, Congo DR, and Tunisia from 1971-2001 using ARDL-bounds testing procedure by Wolde-Rufael (2006); for eight net energy importing and exporting countries from 1971-2002 using panel error-correction model by Mahadevan and Asafu-Adjaye (2007); for Hong Kong from 1966-2002 using VECM by Ho and Siu (2007); for China from 1978-2004 using Johansen Maximum likelihood procedures and Hodrick–Prescott filter by Yuan, Zhao, Yu, and Hu (2007); for Fiji islands from 1971-2002 using ARDL-bounds testing procedure by Narayan and Singh (2007); for G7 countries from 1972-2002 using panel cointegration, Granger causality, and structural breaks by Narayan and Smyth (2008); for nine OECD countries with varying samples using bootstrapped causality tests by Narayan and Prasad (2008); for Nigeria from 1980-2006 using VECM co-feature analysis by Akinlo (2009); for Tanzania from 1971-2006 using ARDL-bounds testing procedure by Odhiambo (2009); for Tunisia from 1971-2004 using VECM by Belloumi (2009); for Greece from 1960-2006 using Toda-Yamamoto causality test by Tsani (2010); for Brazil, India, Russia, and China from 1965-2009 using Granger causality by Pao and Tsai (2010); for South Africa and Kenya from 1972-2006 using ARDL-bounds testing procedure by Odhiambo (2010); for nine South American countries from 1980-2005 using Panel cointegration causality tests by Apergis and Payne (2010); for thirty sub-Saharan countries from 1980-2008 using Panel cointegration casuality tests by Al-mulali and Sab (2012); for Angola from 1971-2009 using ARDL-bounds testing VECM causality test by Solarin and Shahbaz (2013); for fifteen ECOWAS countries from 1980-2008 using Panel cointegration causality tests by Ouedraogo (2013); for China from1971-2011 using ARDL-bounds tests Granger causality by Shahbaz, Khan, and Tahir (2013); for Pakistan from 1972-2010 using cointegration and Granger causality by Tang and Shahbaz (2013); for Greece from 1960-2008 using Parametric and non-Parametric causality tests by Dergiades, Martinopoulos, and Tsoulfidis (2013); for USA from 1973-2012 using Wavelet analysis Granger causality by Aslan, Apergis, and Yildirim (2014); and for Brazil and Uruguary from 1972-2006 using ARDL-bounds testing procedure by Odhiambo (2014).

Electricity Consumption and Economic Growth of Pakistan

One of the pioneer studies from 1955-1995 of Pakistan by Anjum Aqeel, and Mohammad Sabihuddin Butt (2001) found that electricity consumption causes economic growth, however, economic growth led to higher consumption of petroleum. Conservation of petroleum will not affect the economic growth but conservation or reduction in the electricity supply will slow down or reduce the economic growth. Thus adoption of policies to maintain a steady supply of electricity for current and future requirements are essential not only for the economy but also for the employment generation and avoiding unemployment (Aqeel & Butt, 2001). The energy consumption of developing countries like Pakistan are not intensive as that of developed countries, Pakistan is said to be agrarian economy with agriculture having a major share in the GDP of the country thus electricity requirements are not so high as the industrialized nations, to check the relation between electricity consumption and GDP, Mushtaq, Abbas, Abedullah, and Ghafoor (2007) found positive uni-directional causality of electricity consumption with GDP from 1972-2005, with direction from electricity consumption to GDP that is, higher electricity consumption led to higher GDP. Mushtaq, Abbas, Abedullah, and Ghafoor (2007) also found that increase in electricity prices have negative consequences and to help agriculture maintain and significantly increase its contribution to the GDP of the country, the government should focus on the infrastructure and should provide electricity at subsidized rates.

Methodology

Historical research based on secondary data sources was used and synthesized for usage, aimed to find the Co-integration and Granger causality between industrial GDP and industrial electricity consumption, between industrial employment and industrial electricity consumption, and between industrial GDP and industrial employment. All available quantitative secondary data without sampling was used from the following sources:

- National Transmission and Despatch Company, Government of Pakistan
- National Electric Power and Regulatory Authority, Government of Pakistan
- Pakistan Economic Survey, Finance Division, Government of Pakistan
- World Development Indicators, The World Bank

The variables used and their conceptual definitions are given below:

- Industrial electricity consumption is the total electricity consumption of all industry of Pakistan in one year
- Industrial electricity demand is the total electricity demand of all industry of Pakistan in one year
- Industrial GDP refers to the sum of all monetary values of all final products of total industry of Pakistan in one year
- Industrial employment refers to all persons employed in industry in Pakistan in one year

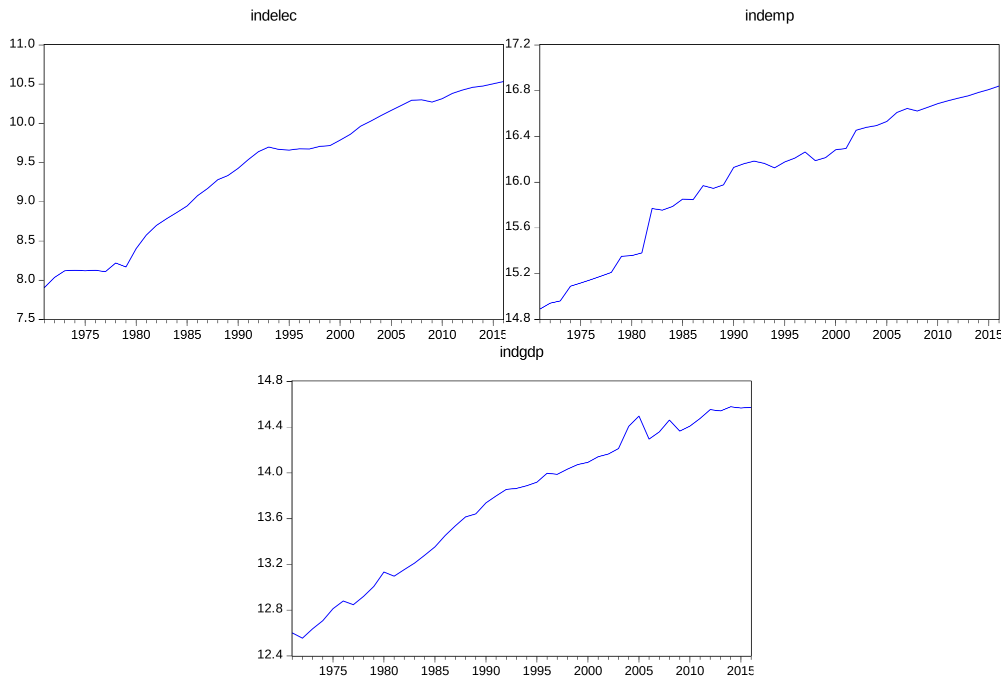

Figure 5. Industrial electricity, industrial employment, and industrial GDP historical behavior

Relation between Industrial Electricity, Industrial Employment, and Industrial GDP

The data for industrial electricity consumption in Giga Watt Hours (GWh) was taken from National Transmission and Despatch Company, industrial GDP, Gross value added at Factor Cost at Constant Local Currency Unit (FCCLCU) in millions of Rupees and industrial employment from World Development Indicators, United Nations. Bivariate models following Wolde-Rufael (Wolde-Rufael, 2006) are:

$I_{gdpt} = f(I_{elt})$ …………………........1

$I_{empt} = f(I_{elt})$………………………..2

$I_{gdpt} = f(I_{empt})$ …………………......3

Where I_{gdp}, I_{el}, and I_{emp} are industrial GDP, Industrial electricity consumption, and industrial employment respectively. The log-linear form of the above are:

$LI_{gdpt} = \alpha_0 + \alpha_1 LI_{elt} + \varepsilon_t$ …………4

$LI_{empt} = \partial_0 + \partial_1 LI_{elt} + \varepsilon_t$ …………....5

$LI_{gdpt} = \beta_0 + \beta_1 LI_{empt} + \varepsilon_t$ ……….6

A log-linear form of industrial GDP was represented by "indgdp", of industrial electricity consumption by "indelec", and industrial employment by "indemp" in E-views.

Stationarity of Variables

Since non-stationary series can lead to spurious correlations, the variables were tested for a unit root. Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test for unit root for the three series, namely Industrial GDP, Industrial Electricity Consumption, and Industrial Employment, were used, the results are:

Table 1: Unit Root Tests to check Stationarity of Industrial GDP, Industrial Electricity Consumption, and Industrial Employment

Description	**Variable**	**Difference**	**Intercept**	**Intercept and Trend**	**Intercept**	**Intercept and Trend**
Industrial GDP	INDGDP	Level	0.0759	0.9839	0.1167	0.9563
	DINDGDP	1st Difference	0.0000	0.0000	0.0000	0.0000
Industrial Electricity Consumption	INDELEC	Level	0.6745	0.9219	0.5018	0.9163
	DINDELEC	1st Difference	0.0004	0.002	0.0004	0.0016
Industrial Employment	INDEMP	Level	0.4245	0.6496	0.3565	0.7379
	DINDEMP	1st Difference	0.0000	0.0000	0.0000	0.0000

All three series were found stationary at 1st difference i.e. integrated of order 1, I (1).

Lag length selection

Before Co-integration appropriate lags need to be determined. Optimal lag lengths found were:

Table 2: Optimal Lag Length Selection

Endogenous Variables		Lag	LogL	LR	FPE	AIC	SC	HQ
INDGDP	INDELEC	3	142.5579	15.00803*	7.57e-06*	-6.121804*	-5.542581	-5.909496*
INDEMP	INDELEC	5	146.8479	7.422783	7.998e-06*	-6.090142*	-5.170664	-5.755318
INDGDP	INDEMP	1	117.6074	210.0005*	1.69e-05*	-5.314639*	-5.06400*	-5.223650*

Johansen's Co-integration (Long-run Estimates)

Co-integration of non-stationary series which are integrated of same order that is, their co-movement, in the long run, can be found by using Johansen Co-integration test. All the three series were found to be co-integrated according to Johansen's Co-integration test results:

Table 3: Co-integration Rank Test

Unrestricted Co-integration Rank Test					
Series	No. of Co-Integration Equations	Trace Statistic	Prob.	Max-Eigen Statistic	Prob.
INDGDP INDELEC	None*	21.65613	0.0052	16.80232	0.0194
	At most 1*	4..853809	0.0276	4.853809	0.0276
INDEMP INDELEC	None*	20.19880	0.0091	15.33677	0.0337
	At most 1*	4.862025	0.0274	4.862025	0.0274
INDGDP INDEMP	None*	17.06228	0.0288	10.76856	0.1662
	At most 1*	6.293721	0.0121	6.293721	0.0121

The cointegrating coefficients for the three series are summarized below:

Table 4: Normalized Cointegrating Coefficients, Standard Errors, and t-Statistics

Normalized Co-integration coefficients (Standard error in parentheses					
INDGDP	INDELEC	INDEMP	INDELEC	INDGDP	INDEMP
1.000000	-0.72051	1.000000	-0.691295	1.000000	-1.009373
SE	(0.01834)		(0.01454)		(0.05330)
t-statistics	-39.2863		-47.5444		-18.9376

Since in the long run the sign of the coefficients is reversed, all three cointegrating coefficients namely INDELEC, INDELEC, and INDEMP indicate increase in industrial electricity consumption is associated with increase in Industrial GDP in the long run, increase in industrial electricity consumption is associated with increase in Industrial employment in the long run, and increase in Industrial employment is associated with increase in Industrial GDP in the long run.

Vector Error Correction Model-VECM

Since all the three series are nonstationary but are I(1), and are integrated as shown by Johansen Cointegration test, Vector Error Correction Model (VECM) that is, the restricted VAR model, was used to check long-run and short-run dynamics of the cointegrated series. Since the series are not the stationary use of unrestricted VAR model would have resulted in the misspecified model. The VECMs are:

$$\Delta LI_{gdpt} = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta LI_{gdpt-i} + \sum_{i=0}^{n} \delta_i \Delta LI_{elt-i} + \varphi W_{t-1} + \mu_t \ldots\ldots\ldots.7$$

$$\Delta LI_{empt} = \gamma_0 + \sum_{i=1}^{n} \gamma_i \Delta LI_{empt-i} + \sum_{i=0}^{n} \chi_i \Delta LI_{elt-i} + \rho Z_{t-1} + \mu_t \ldots\ldots\ldots.8$$

$$\Delta LI_{gdpt} = \lambda_0 + \sum_{i=1}^{n} \lambda_i \Delta LI_{gdpt-i} + \sum_{i=0}^{n} \omega_i \Delta LI_{empt-i} + \phi V_{t-1} + \mu_t \ldots\ldots.9$$

W, Z, and V are the error correction terms (ECT) and are the residuals from long-run cointegrating regression of the forms represented by equation 4, equation 5, and equation 6 respectively. The cointegrating equations are defined as:

$$W_{t-1} = ECT_{t-1} = LI_{gdpt-1} - \alpha_0 - \alpha_1 LI_{elt-1} \ldots\ldots\ldots 10$$

$$Z_{t-1} = ECT_{t-1} = LI_{empt-1} - \partial_0 - \partial_1 LI_{elt-1} \ldots\ldots\ldots 11$$

$$V_{t-1} = ECT_{t-1} = LI_{gdpt-1} - \beta_0 - \beta_1 LI_{empt-1} \ldots\ldots\ldots 12$$

φ, ρ, and ϕ, the coefficients of error correction terms W, Z, and V respectively, represent how quickly the endogenous variable returns to equilibrium after a change in the exogenous variable, and should be negative, significant, and with value between 0 and -1. The estimated VECMs are shown below:

D(INDGDP) = C(1)(INDGDP(-1) - 0.720510109259*INDELEC(-1) - 6.98024370586) + C(2)*D(INDGDP(-1)) + C(3)*D(INDGDP(-2)) + C(4)*D(INDGDP(-3)) + C(5)*D(INDELEC(-1)) + C(6)*D(INDELEC(-2)) + C(7)*D(INDELEC(-3)) + C(8)*

D(INDEMP) = C(1)(INDEMP(-1) - 0.691294808537*INDELEC(-1) - 9.55055539105) + C(2)*D(INDEMP(-1)) + C(3)*D(INDEMP(-2)) + C(4)*D(INDEMP(-3)) + C(5)*D(INDEMP(-4)) + C(6)*D(INDEMP(-5)) + C(7)*D(INDELEC(-1)) + C(8)*D(INDELEC(-2)) + C(9)*D(INDELEC(-3)) + C(10)*D(INDELEC(-4)) + C(11)*D(INDELEC(-5)) + C(12)*

D(INDGDP) = C(1)(INDGDP(-1) - 1.00937259756*INDEMP(-1) + 2.44389973586) + C(2)*D(INDGDP(-1)) + C(3)*D(INDEMP(-1)) + C(4)*

The estimated VECMs with substituted coefficients are:

D(INDGDP) = - 0.417550304547(INDGDP(-1) - 0.720510109259*INDELEC(-1) - 6.98024370586) + 0.145551083034*D(INDGDP(-1)) - 0.29186573385*D(INDGDP(-2)) + 0.130069399709*D(INDGDP(-3)) - 0.161515074174*D(INDELEC(-1)) + 0.188081105159*D(INDELEC(-2)) - 0.252172346375*D(INDELEC(-3)) + 0.0593335421054 ………………………..13*

D(INDEMP) = - 0.370151062208(INDEMP(-1) - 0.691294808537*INDELEC(-1) - 9.55055539105) + 0.432135490419*D(INDEMP(-1)) - 0.250237843748*D(INDEMP(-2)) + 0.292192734903*D(INDEMP(-3)) + 0.118781794525*D(INDEMP(-4)) + 0.346879102939*D(INDEMP(-5)) + 0.532392257573*D(INDELEC(-1)) + 0.0976882345682*D(INDELEC(-2)) - 0.688886155634*D(INDELEC(-3)) + 0.662538253752*D(INDELEC(-4)) - 0.560582711845*D(INDELEC(-5)) - 0.00163129971152………………………..14*

D(INDGDP) = - 0.283039655481(INDGDP(-1) - 1.00937259756*INDEMP(-1) + 2.44389973586) - 0.0516677302934*D(INDGDP(-1)) - 0.0529244140057*D(INDEMP(-1)) + 0.050470556988………………………...15*

The co integrating equation (long-run models) are:

*Wt-1 = ECTt-1 = 1.0000*INDGDP (-1) - 0.720510109259*INDELEC (-1) - 6.98024370586……….16*

*Zt-1 = ECTt-1 = 1.0000*INDEMP (-1) - 0.691294808537*INDELEC (-1) - 9.55055539105…….17*

*Vt-1 = ECTt-1 = 1.0000*INDGDP (-1) - 1.00937259756*INDEMP (-1) + 2.44389973586..........18*

The values of φ, ρ, and ϕ, the coefficients of error correction terms W, Z, and V are -------0.417550, -0.370151, and -0.283040 respectively. To ascertain long-run causality p-values were found as:

Table 5: Coefficients of Error Correction Terms

Method: Least Squares (Gauss-Newton/ Marquardt steps)				
Coefficient	**Value**	**Std. Error**	**t-statistics**	**Prob.**
φ	-0.41755	0.164864	-2.532697	0.0161
ρ	-0.370151	0.240112	-1.541578	0.1344
ϕ	-0.28304	0.086214	-3.282972	0.0021

The values of φ, ρ, and ϕ are all negative between 0 and -1 signifying speed of adjustment towards long-run equilibrium of explanatory variables electricity and employment for the cointegrating equations 16, 17, and 18 respectively, both φ, and ϕ are significant at 5%, whereas, ρ is significant at 13.5%. The p-values for short-run causality were found to be:

Table 6: Wald Test for Short Run Granger Causality

Wald Test						
VECM Model	**Null Hypothesis**	**Test statistics**	**Value**	**Df**	**Prob.**	**Conclusion**
INDGDP-INDELEC	C(5)=C(6)=C(7)=0	F-statistics	1.0307	(3, 34)	0.3913	INDELEC does not Granger cause INDGDP in the short run
Equation 13		X^2 statistics	3.0921	3	0.3776	
INDEMP-INDELEC	C(7)=C(8)=C(9)= C(10)=C(11)=0	F-statistics	8.6523	(5, 28)	0.0000	INDELEC Granger cause INDEMP in the short run
Equation 14		X^2 statistics	43.261	5	0.0000	
INDGDP-INDEMP	C(3)=0	F-statistics	0.1498	(1, 40)	0.7007	INDEMP does not Granger cause INDGDP in the short run
Equation 15		X^2 statistics	0.1498	1	0.6986	

Table 7: Granger Causality Test Results

		VEC Granger Causality/ Block		Pairwise Granger Causality Tests		
Equation	Null Hypothesis	X^2 statistics	P-value	F-Stat	Prob.	Conclusion
Equation 13	INDELEC does not Granger cause INDGDP	3.092107	0.3776	1.03339	0.3894	Fail to Reject Ho
Equation 14	INDELEC does not Granger cause INDEMP	43.26164	0.0000	8.00902	7E-05	Reject Ho
Equation 15	INDEMP does not Granger cause INDGDP	0.149889	0.6986	10.1443	0.0027	Fail to Reject Ho

Table 8: LM test for Serial Correlation

VECM Model	**Breusch-Godfrey Serial Correction LM Test**	
INDGDP INDELEC	Prob. F (3,31)	0.9371
Equation 13	Prob. Chi-Square (3)	0.9076
INDEMP INDELEC	Prob. F (5, 23)	0.1739
Equation 14	Prob. Chi-Square (5)	0.0553
INDGDP INDEMP	Prob. F(1, 39)	0.6206
Equation 15	Prob. Chi-Square(1)	0.5973

INDELEC has long run relationship with both INDGDP and INDEMP, thus, availability of electricity to industrial sector will not only increase industrial GDP but also industrial employment in the long run as indicated by the p-values of φ, ρ, and ϕ, however, no short run Granger causality was found from INDELEC to INDGDP and from INDEMP to INDGDP. INDELEC Granger causes INDEMEP in the short run, thus, disruption in the availability of electricity to industrial sector will increase industrial unemployment and vice versa. The residual diagnostics using LM test was performed to check for serial correlation and no serial correlation was found in any of the models at 5% significance, the results are presented in Table 8.

Stability diagnostics results also indicated that all models are dynamically stable as shown in the following graphs:

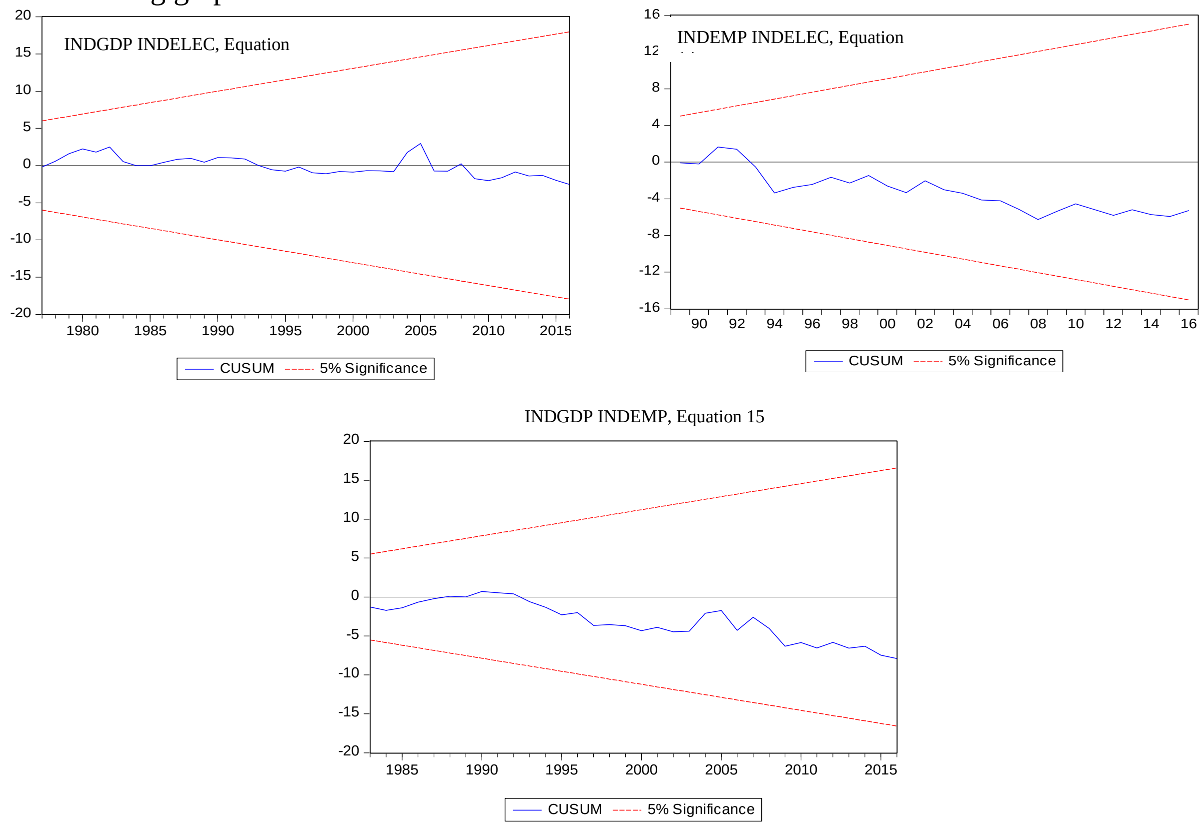

Figure 6. Stability diagnostics for VECMs 13, 14, and 15

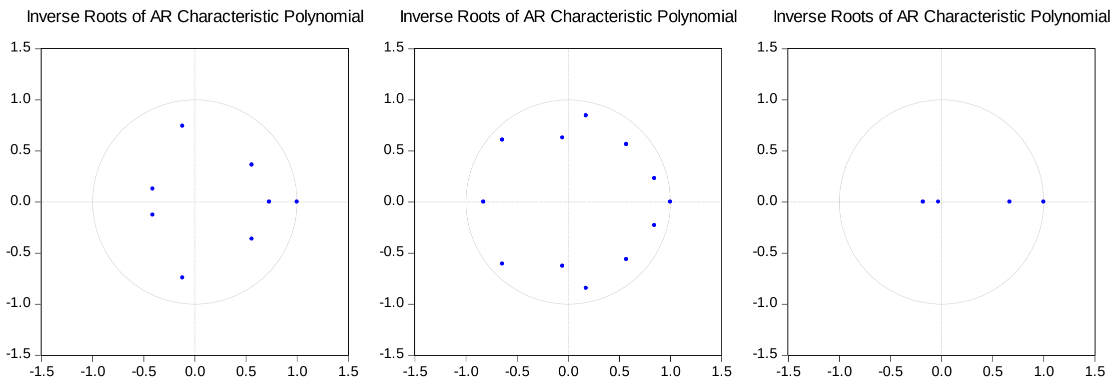

Figure 7. Inverse Roots INDGDP INDELEC, INDEMP INDELEC, INDGDP INDEMP

Conclusion

One of the biggest barriers to economic growth is the availability of reliable energy sources particularly electricity. Unavailability of electricity to manufacturing concerns in Pakistan has resulted in substitution of generators usually diesel to compensate for the unavailable electricity from national grid, resulting not only in transference of capital but also in high production costs, furthermore, with electricity outages labor productivity has gone down due to increased idle time but also has resulted in unemployment. World Bank study of Pakistan showed more than 75% of manufacturing concerns have proclaimed electricity shortage to be the biggest constraint of growth and operations (Grainger & Zhang, 2017). Manufacturing is the second largest economic sector of Pakistan with 80% share of Large Scale Manufacturing (LSM), Iron and Steel Products, Electronics, Paper and Board, Engineering Products, Food, Beverages and Tobacco, Wood Products have shown negative growth in 2016 because of electricity shortages (Government of Pakistan, 2016). Power outages have continuously interrupted manufacturing operations resulting in wastage of material and time, higher costs, inefficient resource allocation, loss of orders and deadlines, one badly hit is textile industry with 23 % loss of textile export share, closure of 150 industrial units causing 30% unemployment (Mustafa, 2017); with electricity shortage being the single most important factor (Jamal, 2017). Small manufacturers and support activities (repair and maintenance) are the worst hit, many have closed their operations, rest waiting idly for the availability of electricity. These are not isolated activities rather are intertwined with one affecting the others, when the industry is not performing support activities are not performing when support activities are unable to carry out commitments the entire industry suffers. This happens vertically and horizontally where one industry is dependent upon other for its inputs, in the absence, delay, inappropriateness in terms of quality or quantity, leads to substitution in the form of imports, which usually are expensive because of tariffs and processing, leading to higher input costs making industry non-competitive. Argument of deindustrialization for Pakistan in not valid for deindustrialization to take place manufacturing value addition remains nearly constant with declining employment in the industrial sector (high labor productivity growth), as observed in the advanced economies, which is not true for Pakistan, this fact has been substantiated by the studies carried out by Yasmin and Qamar (2013), Hamid and Khan (2015) , and Rodrik (2016), rather premature deindustrialization, first used by Rodrik (2016) is the case. Pakistan's deindustrialization is happening earlier as dictated by history, and this deindustrialization is greatly hampering economic growth of Pakistan which is repeatedly confessed by the Government of Pakistan, as mentioned earlier. Manufacturing sector being technologically dynamic, significant absorber of unskilled labor, not restricted to demand constraints of low-income home consumers rather capable of expanding and employing workers if the rest of the economy is technologically stagnant, if deindustrialized means the engine through which growth takes place is removed, which will put developing economies in serious growth and employment constraints as found by Rodrik (2014).

Long-term relation between industrial electricity and industrial GDP with industrial GDP dependent on the supply of industrial electricity, industrial employment dependent on the provision of industrial electricity both in the short run and long run is a testimonial to above. The dependence of industrial GDP on industrial employment is also in lieu with previous research works as industrial employment will increase so will the available income which will lead to the demand of goods and hence manufacturing of the same.

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