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Energy Consumption, Manufacturing Output and Economic Growth in Pakistan: An ARDL Bound Testing Approach

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Abstract
The study investigates the short and long run relationship between energy consumption (DEN), manufacturing output (MG) and economic growth (EG), in Pakistan by applying ARDL bound testing approach. The time series employed is covering the period from 1981 to 2014. With Error Correction Model, our findings exhibit that both energy consumption and manufacturing output has established a positive long run relationship with economic growth. Moreover, by using the granger causality, the results provide the unidirectional causal relationship between manufacturing output and economic growth whereas, a bidirectional causality has been found between energy consumption and manufacturing output. The study implicates that Pakistan needs to enhance the capacity of the energy sector for the efficacy of the manufacturing productivity leading to economic growth. Since, Pakistan is facing an energy shortfall it is necessary for the policy makers to take restructuring of energy sector into account, including capacity enhancement while considering environment and eco-friendly renewable energy sources.
Keywords: Manufacturing output, energy consumption, economic growth, ARDL bound testing, Granger causality.
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1. Introduction

In last two decades, economic growth in uncertain conditions, has been a grave concern for the policy makers of Pakistan. With its 9% growth rate in 1970s, Pakistan reached to 7.5 percent in 2004-05 dipping to the 5.5 percent in (2006-07) as in PES (Pakistan Economic Survey, 2017-18). The historical census presents the downward trend of growth levels of the country. Many studies have been conducted by associating economic growth with volatile productivity levels in the developing countries like Pakistan. As for economic growth associated with inefficient structural growth may bring problems in developing countries (chontanawat. et al. 2008).

The structural growth accounting for 31, 20 and 50 percent of agriculture, manufacturing and service sectors respectively in 1980's, the contribution to GDP of country's manufacturing and service sector is improved to 25% and 53% till 2010 respectively whereas, agricultural sector has been dropped to merely 21 percent as mentioned in PES, 2017. It exhibits that a labor abundant country with population of 199 million(estimated) has significantly changed its policies towards sectoral growth within the country. But the percentage of manufacturing sector has grown merely from 20 to 25 percent in last 30 years. Though, the percentages show the sectoral changes and growth but has not remained inconclusive to enhance the real output of the country. Specifically, the efficacy of the industry related productivity, has been reduced in recent decades adding comparatively less amount to the economy of the country.

Among major productivity sectors of Pakistan, manufacturing sector has always remained a major player for economic growth but has been remained volatile in past decades as per political and economic conditions of the country. Manufacturing output accounted for 13.5 percent of GDP in 2017-08 but has significantly reduced from its share of 18 percent to GDP in 2005-06 PES (2017-18). Whereas, the contribution of manufactured and semi manufactured primary commodities to exports rose to 79 percent in 2004-05 as compared to 28 percent in 1972-73. From the census, it can be observed that though manufacturing is a major sector contributing to exports but it's overall contribution to GDP is reduced in recent decade. Siddique et al. (2011) relates the drop in industrial growth with energy crises of Pakistan reducing the production by 12%.

For the economic growth of a country, energy consumption is considered as an important input to allow their sectoral growth. But since the work of Kraft and Kraft (1978) three decades ago, the energy-growth nexus has been a controversial among researchers and scholars. Mirza & Kanwal. (2016) provides that energy consumption granger causes CO_2 emissions which causes economic growth. It further provides that the causality between energy consumption and economic growth is related with CO_2 emissions. The study proves that that energy led growth hypothesis is valid in Pakistan. As given by Tang & Shahbaz, 2013, the major energy consumer among all sectors in Pakistan is manufacturing sector providing granger causality. The paper further proves that energy consumption granger causes manufacturing output in Pakistan. Though on the contrary to the study of Mirza & Kanwal. (2016), Shahbaz & Faridun. (2011) brings no causality between CO_2 emissions and economic growth. From these studies we can atleast infer that that energy consumption and CO_2 emissions have bidirectional causality. Whereas, chontanawat et al., (2008) provides that irrespective of long and short run relationship, the energy consumption doesn't necessarily granger cause economic growth in developing countries like Pakistan. Therefore, the debate on energy-growth nexus in developing countries bring different arguments based on research findings.

Adding to the intensive research literature of energy-growth hypothesis, our study emphasizes on the short and long run relationship between energy consumption, manufacturing output and economic growth in Pakistan while using ARDL bound testing approach. We further provide the evidence of the direction of causality among the variables by using Granger Causality analysis.

The paper has been further divided as follows. Section 2 explains the data description, section 3 focuses on the methodologies. Section 4 presents the results and Section 5 provides with the conclusion.

2. Data Description

The variables for our study have been taken from World Development Indicators (WDI) from the period of 1981-2014. The variables considered are GDP per capita, Manufacturing output (percentage of GDP) and Energy usage per capita (kg of oil equivalent per capita). All these variables present real values measured in USD (US Dollars) held constant at 2010. To harmonize the data, we have taken log of all the variables. we further have also taken the first differences of variables turning GDP per capita into economic growth (DEG), manufacturing growth (MG) and Energy usage to Change in Energy consumption (CEC). Appendix A further provides the detailed information of the variables.

Table 1. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
EG	34	0.020349	0.017249	-0.0146	0.053334
MG	34	-0.00161	0.069808	-0.29913	0.108253
DEN	34	0.012459	0.019946	-0.03737	0.062143

3. Methodology

To ascertain the effects of energy consumption and manufacturing output on economic growth, our study relies on the ARDL bound testing method of Pesaran et al. (2001). ARDL method calculates both short and long run estimates through linear transformation technique. Moreover, ARDL approach is more suitable in case of mixed stationarity at I (0) and I (1).

The first step before applying ARDL is to investigate the cointegration among variables. Where null hypothesis $H_0 = Y_1 = Y_2 = Y_3 = 0$ is tested against its alternative hypothesis $H_1 \neq Y_1 \neq Y_2 \neq Y_3 = 0$. Based on the calculation of F statistics, we analyze the upper and lower bound limits for rejection or acceptance of null hypothesis respectively. Contrarily, if the value remains in between the upper and lower limits we consider the results inconclusive. For the upper and lower bound limits, we trust the bound test values of Narayan, (2005).

In our case, the sample contains mixed stationarity therefore, ARDL approach is the most appropriate method for our estimations to calculate the long and short run elasticities.

For the ARDL approach, with UECM (Unrestricted Error Correction Model), we have considered,

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{f} \omega_i \Delta EG_{t-i} + \sum_{i=0}^{g} \delta_i \Delta MG_{t-i} + \sum_{i=0}^{h} \phi_i \Delta DEN_{t-i} + Y_1 EG_{t-1} + Y_2 MG_{t-1} + Y_3 DEN_{t-1} + u_t$$

Where Δ is the first difference operator; ω, δ, ϕ are the coefficients for EG, MG and DEN; u_t is the error term; and f, g, h is the lag length selected by Akaike Information Criteria (AIC). We further, have conducted Durbin Watson (DW) and LM test for autocorrelation and white test for heteroskedasticity.

The ARDL model does show the long and short run relationship but does not show the direction of causality. Granger (1998) establishes that the existence of long run relationship at least causes unidirectional causality of the variable. To find the direction, we will apply granger causality while considering the framework of VECM:

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{q} \partial_i \Delta EG_{t-i} + \sum_{i=0}^{r} \emptyset_i \Delta MG_{t-i} + \sum_{i=0}^{s} \theta_i \Delta DEN_{t-i} + \rho_3 ECM_{t-1} + \varepsilon_{2t}$$

Where Δ is the first difference operator; ω, δ, ϕ are the coefficients for EG, MG and DEN; u_t is the error term; and f, g, h is the lag length selected by Akaike Information Criteria (AIC). $ECM_{t-1}$is the error correction term in consideration of long-run relationship. Whereas, its coefficient ρ_3 is the speed adjustment to the long run equilibrium.

4. Results

While looking into the graphs in Figure 1, it can be observed that Economic growth (EG) has an increasing trend yet has a steady surge with little fluctuations. Whereas, manufacturing output (MG) has severe fluctuations being observed after 2000. Similarly, if observed the energy consumption (CEC) the fluctuations can be observed from

2004 onwards, therefore it is worth to consider the long and short run relationship of regressors and dependent variable.

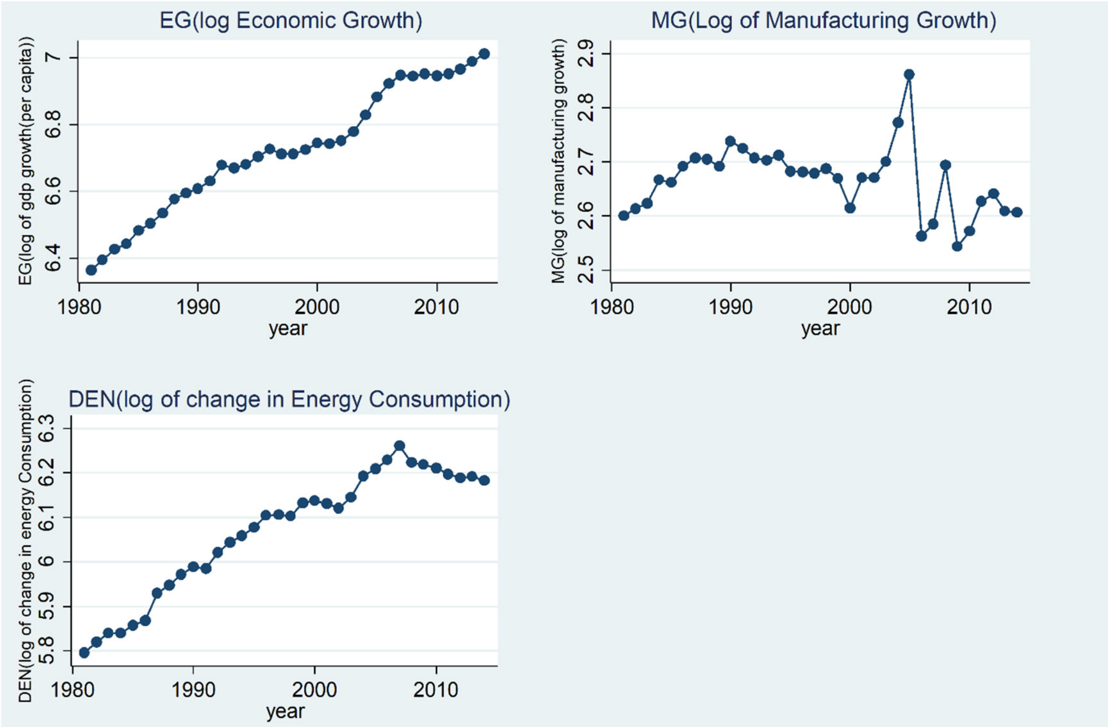

Figure 1. Time trends of EG (log Economic Growth), MG (log of manufacturing growth), DEN (log of change in Energy Consumption). The time series is from 1981-2014.

4.1. Unit root analysis:

It is necessary to check for the level of stationarity to estimate the long and short run dynamics between variables. Otherwise the results could be biased or may show inconsistency. Another reason of considering stationarity test is of any variables integrated with order 2 might not allow us to use ARDL-bound testing approach. Therefore, in our first step for empirical analysis, Augmented Dickey Fuller (ADF) test by Dickey and Fuller (1979) has been considered for the variables of interest. By conducting the test, table 1 exhibits that the Economic Growth (EG) is found stationary at I (1), Manufacturing output growth (MG) and Energy consumption (CEC) has been found stationary at first difference I (0). Since the results of integration are found mixed, we estimate our results on the basis of ARDL approach. In table 3 we present the variables with their order of cointegration.

Table 2. ADF (Augmented Dickey Fuller test)

Variable	I (0) At level				I (1) At first Difference			
	Without Trend		With Trend		Without Trend		With Trend	
	Z-Value	P-Value	Z-Value	P-Value	Z-Value	P-Value	Z-Value	P-Value
EG	-3.130	0.024	-3.129	0.100	-5.131	0.000	-5.073	0.000
MG	-7.379	0.000	-7.440	0.000	-10.222	0.000	-10.042	0.000
DEN	-3.107	0.026	-3.968	0.010	-6.394	0.000	-6.280	0.000

Table 3. Integration Decision:

Variable	Integration
Economic Growth (EG)	I (1)
Manufacturing Growth (MG)	I (0)
Change in Energy Consumption (DEN)	I (0)

4.2. Bound Testing Results:

The next step considered after confirming for the ARDL estimations is to find the cointegration and optimal lag selection. By applying bound testing approach, we estimate the F statistics. However, before cointegration tests, optimal lag selection is important. In our study, we select lag length 2 while taking VAR lag selection of Akaike information criteria (AIC) into account. For bound testing approach, we confirm that the cointegration exists among the variables as the value of F statistic lie above than. We present the results in table 4 for the cointegration test. The values of upper and lower bound has been taken from Pesaran et al. (2001).

Table 4. Results of bound F statistics and diagnostic tests:

Test Statistics		Values
F-Statistics		11.735
Bounds		
Significance	I (0) Bound	I (1) Bound
10%	2.72	3.77
5%	3.23	4.35
2.50%	3.69	4.89
1%	4.29	5.61

4.3. ARDL long run and short run dynamics:

The results of bound testing approach provide with the existence of long run relationship between variables considered. The long and short run estimates have been reported in table 5. The results indicate that the coefficients of manufacturing output (MG) and energy consumption (CEC) are positively significant in both short and long run found consistent with the findings of Mirza & Kanwal. (2016). The manufacturing output presents the positive relation with economic growth but not very significantly in long run. The results provide an evidence that with the 1 % increase in energy consumption (CEC) surges Economic Growth by 0.64 % and 0.43% in long and short run respectively. Whereas, looking into the coefficients of manufacturing growth we find its positive relation with economic growth. It indicates that with an increase of 1% in manufacturing growth increases economic growth by 0.8 percent in short run whereas, 0.25% in long run. Though the long run estimates are not found very significant, yet the sign shows positive association with economic growth. While considering the error correction term, it shows negative yet statistically significant relation confirming the earlier tests conducted for long run relationship of regressors with dependent variables. The coefficient of error correction term shows the speed adjustment for the long-run equilibrium corrected at 75 percent of its first quarter. Furthermore, we have conducted Durbin Watson test for serial correlation and heteroscedasticity between the variables exhibit the non-rejection of null hypothesis. For serial correlation, we have conducted LM and Durbin-Watson (DW) tests and White test for heteroskedasticity. By conducting these tests, we exhibit the non-rejection of null hypothesis. After establishing the long run relationship of MG and CEC with Economic Growth, it is important to observe the direction of causality. To estimate the causality, we run VECM granger causality approach. The results presented in table 6 indicate unidirectional causality of Manufacturing Growth causing Economic Growth whereas, bidirectional causality has been found between energy consumption and manufacturing growth. Yet, there is no causality found between energy consumption and economic growth. Since Pakistan is one of the developing countries, the degree of causality between energy consumption and economic growth is less likely to be prevalent as provided by chontanawat et al. (2008).

Table 5. ARDL long and short run estimations:

Dependent Variable: Economic Growth		
	Coeff(SE)	Tstat(Prob)
Long Run Analysis Lag length (1,2,0)		
MG	0.254^	1.74
	(0.146)	(0.093)
DEN	0.496*	2.67
	(0.186)	(0.013)
Short Run Analysis, Lag Length (1,2,0)		
Δ EG(t-1)	0.246	1.66
	(0.149)	(0.11)
Δ MG	0.0367	0.90
	(0.041)	(0.378)
Δ MG(t-1)	0.090*	2.27
	(0.039)	(0.032)
Δ MG(t-2)	0.065	1.46
	(0.045)	(0.156)
Δ DEN	0.374*	2.62
	(0.143)	(0.015)
ECM(t-1)	-0.754***	-5.07
	(0.149)	(0.000)
Intercept	0.0103*	2.76
	(0.004)	(0.010)
N	32	
R-sq	0.590	
Diagnostic Tests	Value	Prob
DW-Statistics	2.154	
LM-Statistics (bgodfrey)	0.923	0.3366
Heteroscedasticity	16.88	0.6607

Note: Coefficients are reported with standard errors in brackets. ***, **, * and ^ indicate significance at 0.001, 0.01, 0.05 and 0.1 levels, respectively. Δ defines the first difference. All of the above estimations are based on the error correction model. (t-1) represents first lag whereas, (t-2) represents second lag. DW statistics and LM statistics test for autocorrelation and Heteroskedasticity is tested with White test.

Table 6. Granger Causality Test:

Variables	ΔEG	ΔMG	ΔEN
ΔEG	_	5.379*	0.191
		(0.020)	(0.662)
ΔMG	0.140	_	4.615*
	(0.708)		(0.032)
ΔDEN	0.454	10.11**	_
	(0.501)	(0.001)	

Note: Coefficients are reported with probabilities in brackets. ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively. Δ defines the first difference.

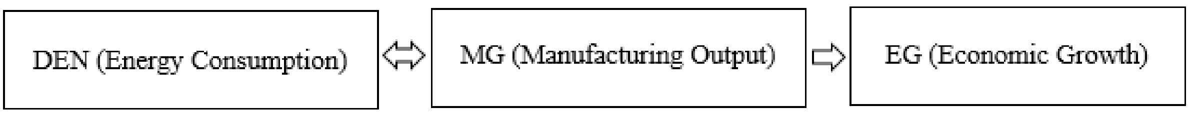

Figure 2. exhibits the significant outcomes of causality tests where energy consumption shows bidirectional causality with manufacturing growth whereas, a unidirectional causality has been found between Manufacturing output and Economic Growth respectively.

⟺ Mentions the bidirectional causality whereas, ⟹ represents unidirectional causality among variables.

5. Conclusion

While considering the importance of manufacturing sector, prevailing energy crises and falling economic growth of Pakistan, we examine the effects of energy consumption and manufacturing growth on economic growth from 1981-2014. For estimation of short and long run effects, we have considered ARDL bound testing approach. The results confirm the positive short and long run relationship of manufacturing growth (though not very significantly) and energy consumption with economic growth. To analyze the direction of causality, we have relied on the Granger causality approach. As for the manufacturing sector, manufacturing output only granger causes economic growth, but economic growth does not granger cause manufacturing output imply unidirectional causality.

Between economic growth and energy consumption we find no granger causality. Whereas, for manufacturing and energy consumption, we present the bidirectional granger causality. It exhibits that level of energy consumption determines the performance of the manufacturing sector which in turn affects the economic growth level. Hence, we can say that manufacturing sector is influenced by the energy sector in Pakistan. Though while considering the ARDL estimations, energy consumption has established a long run relationship with economic growth but in terms of causality it relates bidirectionally with the manufacturing growth which leads to economic growth. At present, the power outrage and energy crises make difficult for manufacturing sector to be efficient. Thus, to achieve economies of scale in manufacturing sector it is important for the policy makers of Pakistan to develop a sustainable energy sector. It will not only help the manufacturing sector of Pakistan but will also assist the other sectors to work effectively. Moreover, with the rise of energy consumption may highly likely cause environmental pollution leading to adverse environmental conditions. Being a member of Kyoto Protocol agreements on clean development mechanism it is necessary for Pakistan to reduce GHS emissions while ensuring energy efficiency. Siddique et al. 2011 provides that industrial sector's productivity has been reduced in Pakistan due to power shortage. Since the energy sector still needs dire attention in the country, it is important for policy makers to consider the renewable energy sources for meeting the demands of sectoral growth leading to economic growth while curbing the CO_2 emissions rising from energy consumption as provided by Arouri et al. 2012.

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