Cross-sectional Electricity Demand Analysis in Egypt

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Abstract

This paper analyzes the electricity demand in Egypt, as a result of the continuing increase in the electric power sector. There comes the importance of focusing on current electric power situation by discussing and analyzing the demand for electricity, using panel dataset for 8 sectors (which are: industrial (C), industrial (D), residential, commercial, agricultural, street-lighting, public utilities and governmental sectors) from 2002 to 2013. Electric power stations mainly depend on non-renewable energy sources by
85 percent, Unit root (ADF) test, Bounds Testing, Autoregressive Distributed Lag (ARDL), and Vector Error Correction Model (VECM) are used as a framework to estimate both, long- and short-run coefficients and allow for deterministic trends.

Results indicate that there is cointegration among variables in electricity demand function. The study also recommended the need for rationalization of energy consumption, more diversifying energy sources to ensure efficiently resources allocating and the tendency to renewable sources.

ملخص

تقدم هذه الورقة تحليلا للطلب على الكهرباء فى مصر نتيجة للزيادة المستمرة فى قطاع الطاقة الكهربائية. و من هنا تأتى اهمية التركيز على الوضع الحالى لقطاع الطاقة الكهربائية بمناقشة وتحليل الطلب على الكهرباء باستخدام بيانات قطاعية لثمانى قطاعات فى الفترة من ٢٠٠٢ الى ٢٠١٣. تم استخدام اختبار جذر الوحدة (ADF) و اختبار الحدود,Bounds Testing و اختبار Autoregressive ARDL بالإضافة الى نموذج تصحيح الخطأ VECM كإطار لتقدير المعاملات طويلة وقصيرة الاجل.

وتشير النتائج الى ان هناك تكامل cointegration بين المتغيرات فى الطلب على الكهرباء. كما اوصت الدراسة بضرورة ترشيد استهلاك الطاقة، وتنويع مصادر الطاقة لضمان كفاءة استعمال الموارد وتخصيص والميل الى مصادر الطاقة المتجددة.

1. Introduction

Electrical energy consumption is continuing to increase in response to the accelerating population growth and the expansion in the development process which is an escalating problem, leading to several power outages in Egypt due to the occurrence of a gap between the quantity of electricity supplied and its quantity demanded. This must be dealt with to achieve a sustainable balance in consumption, considering the rise of oil prices and resources scarcity. To meet the growing needs of the population in the consumption of electricity, consuming countries should move on the first two levels: rationalization of using existing energy sources, especially; oil and natural gas and electricity, and the second: the development of new energy sources from non-traditional sources such as solar energy and wind energy and hydropower, helping to reduce dependence on non-renewable sources of energy, including save future generations their right to life and to development. The reliance on fossil fuels alone is not sufficient to meet the requirements of development and the needs of the population, with the rise of its prices internationally. On the other hand, solar energy and wind energy and electric power of mobile costs represent a viable alternative and a friend of the environment, in the stage after oil depletion, in addition to being less polluting the environment, and the expansion, in these alternatives, reduces the size of the great support of the state oil derivatives, which placed a heavy burden on the citizen and the State.

However, the average per capita share of electricity consumption is one of the most important indicators of the economic progress. A remarkable development has been witnessed by the electricity sector in Egypt during the past two decades, represented in the increase in individual share in electricity consumption as a result of the implementation of development plans in the State. Thus, this paper aims to analyze the function of sectoral electricity consumption using a dynamic model of panel data with application to Egypt during the period (2002-2013), in the light of the huge expansion in the production of electricity, urbanization, population growth, and industrial sectors.

2. Methodology

Analyzing the function of sectoral electricity consumption came through three sections; model used and configuration data, Unit root test to discuss stationarity of the variables, and Cointegration by using the Bounds Testing approach built on the Autoregressive Distributed lags (ARDL). Finally, the impact of demand for electricity on sustainable development is discussed in three sections; model used and configuration data, Unit root test to discuss stationarity of the variables, and Cointegration by using the Bounds Testing approach built on the Autoregressive Distributed lags (ARDL).

2.1.Model used:

The methodology of the study mentioned that demand for electricity function will take the following form:

Where $Cons_{it}$ represents dependent variable (electricity consumption

$$Cons_{it} = \beta_0 + \beta_1 AVPrice_{it} + \beta_2 GDPc_{it} + u_t$$

in K.W.h), *i* refers to electricity demand sectors, *t* refers to time period of the study (2002 – 2013), *AvPrice* refers to average price of electricity in Pts, *GDPc* refers to GDP per capita growth rate, while $\beta_{1,2}$ represents coefficients of variables, β_0 refers to constant coefficient, and u_t refers to error term.

Data were processed by taking double log to fix the autocorrelation problem in the panel set. Descriptive statistics of the variables and their correlation matrix are shown in tables (1) and (2) in the annexes.

2.2.Unit root test:

Despite the fact that one of the advantages of ARDL method is that it can be done whether an integrated package of the same degree; any of the superior I(0)or I(1), or integrated to different degrees, I(0) and I(1), but the only condition for the application of this test is not to be the time series of an integrated package of second class I(2). Thus, the first step is the verification of the stationarity of variables by using Unit Root Test.

There are three different tests to verify the robust of the results: Levin, Lin, and Chut test, Lm, Pesaran, and Shin test, and the ADF - Fisher test, where are considered the most commonly used in applied research, as follows:

Fisher - ADF test combines the values of *p* from the unit root test for each sector *i*. Thus, distribution of Chi^2 with degrees of freedom of 2n, where n is the number of sectors in panel data. The Statistical testing is as follows:

$$\lambda = -2\sum_{i=1}^{n} \text{loge}(\rho i)$$

Where (ρi) represents *p* value to test Augmented Dickey Fuller ADF)for each sector *i*).

Also, LLC and IPS tests depend on the regression equation of ADF. LLC test takes the following formula:

$$\Delta Y_{i,t} = \alpha_i + \rho Y_{i,t-1} + \sum_{K=1}^{n} \emptyset_k \, \Delta Y_{i,t-k} + \delta_i t + \theta_t + \mu_{it}$$

Where it takes into consideration, sectoral fixed and time effects through the coefficients α_i) and θ_t).

Testing the null hypothesis assumption of the presence of unit root $H_0: \rho =$ 0), and for the alternative hypothesis that there is not unit root $H_0: \rho > 0$). But the negativity of LLC test restricts the (ρ) to be homogeneous across sectors, so the IPS test was expanded to allow variable changing parameter $Y_{i,t-k}$) across sectors, it takes the following formula:

$$\Delta Y_{i,t} = \alpha_i + \rho Y_{i,t-1} + \sum_{K=1}^{n} \emptyset_k \, \Delta Y_{i,t-k} + \delta_i t + \mu_{it}$$

And ADF Fisher test is done to each sector *i*, which accepts the various of coefficient values, the variance of residuals, and lag length.

It is clear from the results of (LLC, IPS, and Fisher-ADF) tests used to analyze stationarity of the variables Consumption, average Price, and GDPC.

At the level of significance 1 percent, they were stationary at Level except for GDPC that became stationary at First difference Intercept; it has an integrated package of grade I(1) at significant level 1 percent. As a result, variables have become integrated at I(0) and I(1), which supports the use of ARDL Test.

2.3.Co-integration test using ARDL:

In ARDL, cointegration model the consumption model will take the following forms:

$$\Delta Cons_{it} = \alpha_i + \varphi_i Cons_{i,t-1} + \delta_i^* avPrice_{it} + \theta_i^* GDPc_{it} + \mu_{it}$$

Where, δ_i^* and θ_i^* refer to long-term coefficients.

In order to test the null hypothesis which refers to the absence of cointegration between variables, the value of F-calculated is compared with the value of F-tabulated from Peseran et al. (2001).

Results showed that the value of F-calculated is greater than the value of the upper limit of the F-Tabulated (UCB) so null hypothesis will be rejected and alternative hypothesis will be accepted instead, meaning that there is cointegration between variables.

3. Results

Results show that average price has a positive impact, significant at the level of 5 percent, on the electricity consumption per capita ($Cons_C$) in Egypt in the long-term, meaning that when (avPrice) increases by one piaster, $Cons_C$ increases by 0.0572 kWh. On the other hand, there is a positive influence and significant at level 1 percent of the GDP per capita (GDP_C) on electricity consumption per capita, meaning that, an increase in GDP_C by one dollar lead to an increase in the electric

power consumption in Egypt at the level of all sectors by 1.3429 kWh in average. Which comes in consistence with the economic theory, presupposed the existence of a positive relationship between income and consumption. But have another outcome for the impact of the change in the electricity tariff since it is an indispensable commodity at which its consumption may be rationalized but can't be disposed of. An analysis of the impact of each sector will be discussed in the following section.
In return, the statistical significance between avPrice, GDP_C, and $Cons_C$ in the short term refers to the ability of the average price and GDP_C to influence.
Thus, demand for electricity function in Egypt can be concluded as follows:

Results show the sectorial analysis, as shown in the appendices, it can be summarized as follows:

1. In the Agricultural sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a negative and significant impact on electricity consumption for the agricultural purposes, while GDPc has no effect.
2. In the Public Utility sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a negative and significant impact on electricity consumption for the public utility purposes, and also GDPc has a negative and significant effect.
3. In the Street Lighting sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a positive and significant impact on electricity consumption for the street lighting purposes, while GDPc has no effect.
4. In the Governmental sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a positive and significant impact on electricity consumption for the governmental purposes, while GDPc has no effect.
5. In the Residential sector, the negative and significant ECM shows

the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a negative and significant impact on electricity consumption for the household purposes, and also GDPc has a negative and significant effect.

6. In the Commercial sector, the Average price has a positive and significant impact on electricity consumption for the commercial purposes, while GDPc has no effect.
7. In the Industrial (B) sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. Average price and GDPc have no effect on electricity consumption for the purposes of heavy industries.

8. In the Industrial (C) sector, the negative and significant ECM shows the stability of the relationship in the long-term and the ability of the error correction mode. The average price has a negative and significant impact on electricity consumption for the manufacturing industrial purposes, and also GDPc has a negative and significant effect.

4. Conclusion

The study aimed to analyze the demand for electricity in Egypt during the period 2002-2013 using panel data of all of its economic sectors including eight sectors which are; industrial (C), industrial (D), residential, agricultural, commercial, governmental, public utilities, street lighting and others. The Bounds Testing, Autoregressive Distributed Lag (ARDL), and Vector Error Correction Model (VECM) were used to achieve the study objectives.

Results came out showing that both average price and GDPc have a positive impact, significant at levels of 5, and 1 percent respectively, on the electricity consumption per capita ($Cons_C$) in Egypt in the long-term. In consistent with the economic theory, presupposed the existence of a positive relationship between income and consumption. But have another outcome for the impact of the change in the electricity tariff since it is an indispensable commodity at which its consumption may be rationalized but can't be disposed of.

5. Recommendations:

Promote and support investment in electrical energy and emphasis on basic infrastructure and expansion through cooperation with the private and public sector institutions, since injecting the economy of developing countries with investments, is acting as a catalyst, where these positive shocks lead to revive the inherited economic structure. As a real cycle of strong investment, increase productivity, reduce costs, increasing incomes and expanding markets, would lead to more investment and increases in productivity, and the mix will include cumulative flashes in the areas of supply and demand which are indispensable for sustainable development. In addition to the importance of the electric linkage for rural development, huge investments in the projects of the rural electricity especially network expanding has been part and parcel of successful growth experiences (the Congress of the United States, the Office of Technology Assessment, 1992).

For example, Germany has developed a long-term program to secure its energy needs after getting rid of nuclear power stations and replaced them by other sources of renewable energy, which do not run out such as the wind, solar, hydro, etc., in generating electricity. Vast fields along the sight were planted of tens thousands of small devices to absorb solar energy into electricity. This is in a country that does not have the sunshine Jan-June like Egypt or even has large areas of the Sahara. So diversification of sources of energy has become a priority, to fill the gap between supply and demand for electrical energy.

6. References

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Appendices

Table 1: Descriptive statistics of the variables.

Obs. 96	Mean	Std. Dev	Max	Min
Cons	0.634893	0.094612	0.861482	0.541057
avPrice	0.098358	0.087688	0.234518	-0.079611
GDPc	0.627287	0.004655	0.632249	0.620247

Source: table constructed by the researcher using E-views 9

Table 2: correlation matrix between variables.

	Cons	*avPrice*	*GDPc*
Cons	1.000000	0.334359	0.109333
avPrice	0.334359	1.000000	0.273966
GDPc	0.109333	0.273966	1.000000

Source: table constructed by the researcher using E-views 9

Table 3: Unit root test results:

Variable	**LLC**		**IPS**		**ADF**	
	Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend
Cons	-0.72125		1.85151		6.33317	
	(0.2354)		(0.9680)		(0.9841)	
ΔCons	-0.95999		-1.94417		29.6537	
	(0.1685)		(0.0259)		(0.0199)	
avPrice	-8.22018		-3.89375		42.6501	
	(0.0000)		(0.0000)		(0.0001)	
GDPc	-7.32154		-2.36543		29.4181	
	(0.0000)		(0.0090)		(0.0213)	

Note: The values in ( ) indicate the P-Value (Prob.). Note: * indicate significance at 10%.

Table 4: Bounds testing results

Regressors: (K = 2)	F-statistic
$Cons_{it} = f(avPrice_{it}, GDPc_{it})$	

K indicate to number of independent variables in the model.

Table 5: ARDL Regression and error correction model estimation: Dependent variable is *Cons*

Variable	Coefficient	Std. Error	t-Statistic	Prob
Long-run				
avPrice	0.057266	0.017080	3.352775	0.0015
GDPc	1.342949	0.085063	15.78767	0.0000
Error Correction coefficient	-0.436137	0.404593	-1.077966	0.2858
Short-run coefficients				
D(***Cons(-1)***)	0.081822	0.274487	0.298090	0.7668
D***(avPrice***)	0.284262	0.142266	1.998106	0.0508*
D(***GDPc***)	-2.418265	0.815552	-2.965187	0.0045
Constant	-0.049460	0.100259	-0.493322	0.6238

Note: * indicates significance at 10%.

Table 6: Analysis of Sectors:

1. Agricultural sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0049	-7.480026	0.054441	-0.407219	COINTEQ01
0.4829	0.798625	0.162778	0.129999	D(LCONS2(-1))
0.0007	-14.31982	0.003571	-0.051130	D(LAVP2)
0.1858	-1.710106	1.061018	-1.814454	D(LGDPC2)
0.0002	-22.75908	0.004837	-0.110082	C

2. Public Utility sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0000	-139.1306	0.008709	-1.211687	COINTEQ01
0.0000	51.05535	0.011697	0.597199	D(LCONS2(-1))
0.0000	-41.76312	0.000110	-0.004581	D(LAVP2)
0.0002	-21.57082	0.199356	-4.300282	D(LGDPC2)
0.0000	-94.48247	0.003540	-0.334453	C

3. Street Lighting sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0143	5.138945	0.375805	1.931243	COINTEQ01
0.0219	-4.392813	0.288262	-1.266283	D(LCONS2(-1))
0.0101	5.820810	0.070377	0.409651	D(LAVP2)
0.3026	-1.241554	4.292754	-5.329686	D(LGDPC2)
0.0005	16.11055	0.033353	0.537335	C

4. Governmental sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0004	-18.33756	0.079788	-1.463114	COINTEQ01
0.0017	10.80217	0.122197	1.319997	D(LCONS2(-1))
0.0000	40.83816	0.020288	0.828541	D(LAVP2)
0.0843	2.544474	0.492800	1.253916	D(LGDPC2)
0.0002	-21.39478	0.018677	-0.399591	C

5. Residential sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0054	-7.238910	0.013312	-0.096365	COINTEQ01
0.0380	3.555022	0.081632	0.290204	D(LCONS2(-1))
0.0000	-182.5084	0.000157	-0.028681	D(LAVP2)
0.9116	0.120626	0.208676	0.025172	D(LGDPC2)
0.0001	-33.89906	0.000461	-0.015628	C

4. Commercial sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0030	8.849264	0.007301	0.064608	COINTEQ01
0.0021	-9.968399	0.066024	-0.658149	D(LCONS2(-1))
0.0002	20.87002	0.044348	0.925549	D(LAVP2)
0.1641	-1.833344	0.828137	-1.518261	D(LGDPC2)
0.0000	45.53909	0.000520	0.023684	C

5. Industrial (B) sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0149	-5.054841	0.128189	-0.647977	COINTEQ01
0.0779	2.635729	0.023712	0.062498	D(LCONS2(-1))
0.8456	0.212101	1.177974	0.249850	D(LAVP2)
0.9499	-0.068233	48.08480	-3.280967	D(LGDPC2)
0.0002	-23.24907	0.004145	-0.096369	C

6. Industrial (C) sector

Prob. *	t-Statistic	Std. Error	Coefficient	Variable
0.0003	-18.95130	0.087518	-1.658588	COINTEQ01
0.0153	5.013763	0.035724	0.179111	D(LCONS2(-1))
0.0454	-3.309498	0.016650	-0.055103	D(LAVP2)
0.0337	-3.724696	1.176353	-4.381557	D(LGDPC2)
0.9426	-0.078253	0.007334	-0.000574	C