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# Mean Reverting Behavior of Energy Consumption: Evidence from Selected MENA Countries

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**ABSTRACT:** This study examines whether the energy consumption for 15 members of the Middle Eastern & North African (MENA) countries is a stationary process over 1971-2010 period. Annual energy consumption data for Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Lebanon, Libya, Morocco, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates and Turkey, is analyzed using the Lagrange Multiplier (LM) unit root test, in which structural breaks in level and/or trend are endogenously determined. The results of the LM test with two breaks showed that the energy consumption per capita in 8 MENA countries is a stationary process. This study suggests that it is possible to design consistent energy policies based on econometric models and forecasts of energy consumption in those 8 MENA countries.

**Keywords:** Energy Consumption; Unit Root; LM test; MENA
**JEL Classifications:** E21; Q43

## 1. Introduction

The interest on the stationarity of energy consumption and production in the literature has expanded significantly in the last decade (see Chen and Lee, 2007; Narayan and Smyth, 2007; Hsu et al, 2008; Maslyuk and Smyth, 2008; Lean and Smyth, 2009; Gil-Alana, Loomis and Payne, 2010; Narayan et al, 2010; Barros et al, 2011; Apergis and Tsoumas, 2011; Barros et al, 2012; Apergis and Tsoumas, 2012). Many studies have focused on energy consumption and fossil fuels (*e.g.* coal, petroleum, natural gas) such as Apergis et al (2010a), Apergis et al (2010b), Apergis and Payne (2010). Therefore, testing the stationarity of energy variables (energy, electricity, oil, coal, petroleum, natural gas etc.) created new research possibilities in the field of energy economics.

Understanding the stationary process of energy consumption can have important implications on energy policies in MENA countries. Recently, researchers have looked at the stationarity of the energy consumption per capita by using different unit root tests. The main objective of this literature has been to examine whether shocks to energy consumption/production have permanent or temporary effects. In conjunction with this literature, this paper focuses on the shocks to energy consumption and tests whether the energy consumption in select countries is a stationary process.

To begin with, if energy consumption follows a stationary process (*i.e.* it does not have a unit root), any shock to energy consumption will have transitory effects. On the other hand, if energy consumption is a non-stationary process (*i.e.* it has unit root), any shock to energy consumption will have permanent effects and the energy consumption will not return back to its time trend. Second, if any shock on energy consumption has a temporary effect, energy consumption will return to its time

trend and such shocks will not disturb macroeconomic policies based on forecasts. In contrast, if shocks to energy consumption have permanent effect, the determination of macroeconomic variables such as output growth is likely to be a non-stationary process as well, which makes conducting macroeconomics policies based on forecasts difficult. Therefore, the effects of energy consumption on other macroeconomic variables are crucial in giving direction to an economy. Third, the stationary process for energy consumption enables us to use the time trend of energy consumption in forecasting future demand and consumption. After any transitory shock to energy consumption, energy consumption per capita will return to its time trend and such shocks will have only temporary effects on the energy consumption. Therefore, the permanent response of electricity consumption to any shock is vital for modeling and forecasting the demand for electricity. In the case of permanent shocks, the time trend of electricity consumption is not relevant to forecasting the future consumption (Chen and Lee, 2007; Mishra et al. 2009; Apergis et al, 2010a; Apergis et al, 2010b; Apergis and Payne, 2010; Hasanov and Telatar, 2011; Smyth, 2013; Kula et al., 2012; Lean and Smyth, 2013).The article is organized as follows: In section 2, we are going to overview the literature of energy consumption testing. The section 3 examines the data, explains the methodology and the empirical results. And finally in section 4, we are going to conclude this study.

## 2. Existing Literature

Beginning with Masih and Masih (1996), the unit root characteristics of energy consumption have been studied by many researchers over the last decade. There is a growing body of empirical research on the stationarity of the energy consumption. Studies most often test for unit root of the energy consumption process. Since existence of unit root in the energy consumption process has important implications, researchers turn their attention more towards testing the stationarity using various econometric methods. Unfortunately, most of these recent studies are inconclusive.

This study is the first attempt to examine the stationarity of energy consumption for 15 MENA countries using LM unit root test with structural breaks covering the period from 1971 to 2010. This paper presented an application of Lee and Strazicich's (2003) method, which includes both intercept-no trend and intercept-trend for unit root, to the energy consumption of 15 MENA countries. There are many studies in the literature, such as Chen and Lee (2007), Mishra et al. (2009), Apergis et al. (2010a, 2010b), that focus on the energy consumption as a stationary process.

**Table 1**. Comparison of previous empirical results from about integration of energy consumption

| Author(s) | Country - Period | Frequency | Method(s) | Result(s) |
|---|---|---|---|---|
| Masih and Masih (1996) | India, Pakistan, Malaysia, Singapore, Indonesia and the Philippines 1955-1990 | Annual | Conventional Unit Root Tests (ADF-PP) | Non-Stationary |
| Cheng and Lai (1997) | Taiwan - 1955-1993 | Annual | Phillips-Perron Tests | Non-Stationary |
| Chan and Lee (1997) | China - 1953-1994 | Annual | ADF Test | Non-Stationary |
| Asafu-Adjaye (2000) | India- Indonesia, Philippines and Thailand 1971-1995 | Annual | ADF and PP Tests | Non-Stationary |
| Soytas and Sari (2003) | 10 Emerging Markets G7 Countries (except China) - 1950-1994 | Annual | DF, ADF and PP Tests | Non-Stationary |
| Altinay and Karagol (2004) | Turkey - 1950-2000 | Annual | Zivot-Andrews Test | Stationary |
| Chen and Lee (2007) | Seven Regions (104 Countries) 1971-2002 | Annual | Panel Unit Root with Structural Breaks (Carrion-i Silvestre) | Stationary |
| Narayan and Smyth (2007) | 182 Countries 1979-2000 | Annual | Univariate and Panel Unit Root Tests | Stationary |
| Hsu et al. (2008) | Five Regions 1971-2003 (84 Countries) | Annual | Panel Unit Root (SURADF) | Non-Stationary |

| | | | | |
|---|---|---|---|---|
| Narayan et al. (2008) | 60 Countries - 1971-2003 | Annual | Panel Unit Root without Structural Breaks and with Structural Breaks | Mixed Results and Stationary |
| Mishra et al. (2009) | 13 Pacific Island Countries 1980-2005 | Annual | Panel Unit Root with Structural Breaks (Carrion-i Silvestre) | Stationary of 60% of the sample |
| Lean and Smyth (2009) | US (Five Sectors) 1973:1-2008:7 | Monthly | Univariate and Multivariate LM Tests | Mixed Results |
| Narayan et al. (2010) | Six States in Australia 1973-2007 | Annual | Lee-Strazicich Univariate Unit Root with Two- Break | Stationary |
| Apergis et al. (2010a) | US (50 States) - 1980-2007 | Annual | Panel Unit Root with Structural Breaks | Stationary |
| Apergis et al. (2010b) | US (50 States) - 1982-2007 | Annual | Panel Unit Root with Structural Breaks | Stationary |
| Apergis and Payne (2010) | US (50 States) - 1960-2007 | Annual | Panel Unit Root with Structural Breaks | Stationary |
| Hasanov and Telatar (2011) | 178 Countries - 1980-2006 | Annual | Conventional Unit Root Tests and New Developed Tests with Structural Breaks | Stationary (mostly) |
| Ozturk and Aslan (2011) | Turkey (Seven Sectors) - 1970-2006 | Annual | LM Tests | Stationary |

## 3. Data, Methodology, and Results

Annual data on energy consumption (kg of oil equivalent per capita) is taken from the International Monetary Fund's *World Economic Outlook* database. The stationarity of energy consumption is examined for a sample of fifteen MENA countries, namely Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Lebanon, Libya, Morocco, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates (UAE), and Turkey. These countries are selected based on the availability of data for the period 1971-2010.

We use univariate unit root tests with structural breaks as proposed by Lee and Strazicich (2003) based on the *Lagrangian Multiplier* (LM) model. This model is based on the findings of Schmidt and Phillips (1992). In addition, the determination of the correct number of breaks is possible with the two-break unit root test suggested by Lee and Strazicich (2003) as well as the one-break test proposed by Lee and Strazicich (2004). Two-break minimum LM test determines the two breaks in level and trend endogenously. The endogenous two-break LM unit root test allows for breaks under both the null and the alternative hypothesis. LM test statistics have two models. First, model A, allows for a change in the level, and second, model C, allows for a change in both the level and the trend. LM test statistic is defined as follows:

$$y_t = \delta' Z_t + x_t, \quad x_t = \beta e_{t-1} + \varepsilon_t \tag{1}$$

where $Z_t$ is a vector of exogenous variables and $\varepsilon_t \sim iidN(0,\sigma^2)$. Model C in the LS test statistics take into account the changes in both trend and level. These changes are defined $Z_t = \left[1, t, D_{1t}, D_{2t}, DT_{1t,}, DT_{2t}\right]'$ where $DT_{jt} = t - TB_j$ for $t \geq T_{Bj} + 1, j = 1,2$ and 0 otherwise. Besides, LM test statistics is determined by regression as follows:

$$\Delta y_t = \delta' \Delta Z_t + \varphi \tilde{S}_{t-1} + u_t \tag{2}$$

where $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$, $t = 2,...,T$ are coefficient vectors received from the regression of $\Delta y_t$ on $\Delta z_t$ and $\tilde{\psi}_x$ is provided by $y_1 - Z_1\tilde{\delta}$. Also, $y_1$ and $Z_1$ indicate the first observation of $y_t$ and $Z_t$, respectively. The null hypothesis is defined as $\phi = 0$ ( i.e. there is unit root). The LM unit root test with two-break uses the break points $\lambda_1 = TB_1 / T, \lambda_2 = TB_2 / T$. LM unit root tests can determine the break points endogenously by means of a grid search indicated below.

$$\mathrm{LM}_{\tau} = \inf_{\lambda} \tilde{\tau}(\lambda) \quad (3)$$

Table 2 shows the results of the unit root tests. The null hypothesis that there is unit root is rejected in 8 countries, namely Egypt, Israel, Lebanon, Libya, Qatar, Saudi Arabia, Syria, and Tunisia. For the rest of the countries (*i.e.* Algeria, Bahrain, Iran, Jordan, Morocco, UAE, and Turkey) we do not reject the null hypothesis. These results show that any shock to energy consumption per capita has transitory effects for 8 countries, meaning that energy consumption will return to its time trend. In these countries, energy consumption is stationary around structural breaks within intercept and slope of the trend. Two structural breaks in the time series are different across countries. For example, several structural breaks are due to events such as wars in Iran, Lebanon, Israel and Libya from 1982 to 1987, the earthquake in Turkey in 1999, the War of Gulf in Saudi Arabia, Syria and Egypt in 1990-1991, and the conflicts in the Middle East (1970-2010).

**Table 2.** LM unit root with two-break test results for energy consumption per capita

| Countries | *k* | TB1 | TB2 | *t* | Countries | *k* | TB1 | TB2 | *t* |
|---|---|---|---|---|---|---|---|---|---|
| Algeria | 6 | 1986 | 1993 | –3.06 | Morocco | 6 | 2001 | 2006 | –2.95 |
| Bahrain | 3 | 1990 | 2006 | –3.49 | Qatar | 7 | 2004 | 2006 | –4.71*** |
| Egypt | 8 | 2000 | 2003 | –3.97** | Saudi Arabia | 2 | 1986 | 1989 | –4.03** |
| Iran | 0 | 1982 | 2004 | –2.83 | Syria | 7 | 1983 | 1988 | –5.03*** |
| Israel | 0 | 1985 | 1991 | –5.81*** | Tunisia | 0 | 1985 | 1988 | –5.46*** |
| Jordan | 2 | 1989 | 2005 | –2.37 | Turkey | 3 | 1999 | 2005 | –3.27 |
| Lebanon | 8 | 1981 | 1992 | –4.08** | UAE | 7 | 1981 | 1996 | –2.57 |
| Libya | 8 | 1983 | 1987 | –4.22** | | | | | |

*Notes: k* is the optimal number of lagged differences in the unit root to correct the serial correlation. TB1 and TB2 indicate the date with two breaks and *t* represents the *t*-statistics. The 1%, 5% and 10% critical values are –4.545, –3.842, and –3.504, respectively. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively.

## 4. Conclusion

The energy literature discusses the distinction between permanent and temporary shocks to energy consumption per capita in order to model energy demand and forecast future trends in energy consumption. The repercussions of structural breaks on the energy consumption are crucial for the success of energy policies. Sustainable energy policies rely heavily on the forecasts of energy demand. In this regard, determining whether shocks to energy demand are permanent or transitory is important for setting feasible goals for sustainable energy policies. If energy consumption per capita is a stationary process, shocks to energy consumption will have temporary effects and the demand will return back to its mean value. The stationarity of the energy consumption makes using forecasts for conducting energy policies possible again. If shocks to energy consumption have permanent effects, such shocks will be transmitted to the other sectors of an economy, making energy policies based on forecasts invalid. Therefore, testing whether the energy consumption has a unit root is essential to any effective and sustainable energy policy.

In this study, we examined the stationarity of energy consumption per capita for 15 MENA countries over the period from 1971 to 2010. The method applied, which was developed by Lee and Strazicich (2003), is an LM unit root test with two-breaks. Test results show that the null hypothesis that there is unit root is rejected in 8 MENA countries, namely Egypt, Israel, Lebanon, Libya, Qatar, Saudi Arabia, Syria, and Tunisia at the 5% significance; whereas it is not rejected in 7 other MENA countries that are Algeria, Bahrain, Iran, Jordan, Morocco, UAE, and Turkey. This result shows that any shocks to energy consumption per capita have transitory effects for 8 MENA countries, meaning that energy consumption will return to its time trend.

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