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Are Shocks to Energy Consumption Persistent? Evidence from Subsampling Confidence Intervals

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Are shocks to energy consumption persistent? Evidence from subsampling confidence intervals

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Abstract

This paper analyzes the persistence property of energy use in 107 countries around the world during 1971-2011 using different subsampling confidence intervals introduced by Romano and Wolf (2001). These confidence intervals are much more informative than the unit root tests and are more robust to misspecification errors as they require fewer assumptions on the nature of data generating process. While providing evidence about the stationarity or non-stationarity of the variables, they also show the degree of persistence and consequently are very informative for the role of government intervention in environmental oriented policies. The findings show that there are three classes of countries in terms of energy use: with explosive behavior (highly populated with high growth economies- 4 countries); non-stationary (developing and highly oil dependent economies- 64 countries); and stationary (generally developed and energy-rich countries- 39 countries). An explosive behavior of energy use would make government

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environmental related policies improbable as they require strict enforcement rules for the policy to be effective. For the nonstationary cases, government interventions can be effective for energy conservation and other environmental oriented policies, while for the stationary cases the effect of government intervention, energy conservation or environmental-oriented demand-management policies would be temporary, and their effects will not last long.

Keywords: Energy use; Confidence interval; Stationary; Persistence; Subsampling.

JEL classification: C22, Q40

1 Introduction

In this paper we investigate the degree of persistence in energy use (hereafter EN) in 107 countries during the period 1971-2011. We argue that constructing confidence sets for the persistence degree of EN is an informative way of analyzing its persistence property. We use different subsampling methods introduced by Romano and Wolf (2001) to calculate the confidence sets and separate stationary ENs from non-stationary ones. The distinction between stationary and integrated ENs is important in several ways. First, if EN follows a stationary process, then shocks to the EN[1] would be transitory, and the future EN can be forecasted based on its past values (Apergis et al., 2010).[2] On the other hand, any shocks to an integrated or non-stationary EN would cause a permanent change in the process, and it will not revert to its previous mean or trend. In other words, a non-stationary variable will drift; while, a stationary process returns to its previous trend or mean. Second, since EN is correlated with many macroeconomic variables, the persistence in the EN can be transmitted to the other macroeconomic variables (Smyth,

[1]These shocks could happen due to environmental protection policies or energy shocks, among others.

[2]Reliable forecasts of future EU play a very important role in economic planning and ensuring energy security. If EU contains a unit root, then forecasting the future EU values based on its past values would result in erroneous forecasts. Therefore, to make an accurate forecast, extra information about key economic variables is required.

2013). For example, if the EN follows a unit root process, then this property would be transmitted to the production and unemployment. So, a negative shock to the EN would raise the unemployment rate, and in order to bring the unemployment rate back to its previous trend, some stimulus policies should be introduced (Smyth, 2013). Third, in econometric modeling it is important to know whether the EN is stationary or has a unit root. For instance, if the EN is a stationary (non-stationary) process, then to examine the causality between the EN and economic growth, one can use these variables in level (first-difference).

The stationarity properties of the EN show that the effect of energy conservation and demand-management policies would be temporary and it will not last long. Thus, an undesired deviation of the EN requires no intervention of the government; while, for a non-stationary EN, the government intervention can be helpful to correct these deviations.

The stationarity and persistence of EN has been examined in different studies mainly using two approaches, namely univariate unit root tests without or with structural breaks (Narayan and Smyth, 2007; Apergis and Payne, 2010; Narayan et al., 2010; Hasanov and Telatar, 2011; Fallahi, 2011; Maslyuk and Dharmaratna, 2012; Cagregado et al., 2012), and panel unit root tests (Chen and Lee, 2007; Narayan and Smyth, 2007; Hsu et al., 2008; Narayan et al., 2008; Mishra et al, 2009; Lean and Smyth, 2012). The unit root statistics only test the null hypothesis that the sum of the coefficients in an $AR(p)$ sequence equals unity, against the alternative hypothesis that this sum is less than unity. Rejecting the null would mean that the process is stationary, however, it will not provide any information about the degree of persistence of the EN.[3]

Another way to examine the stationarity of time-series data is constructing the bootstrap[4] confidence interval for the largest autoregressive coefficient or for the sum of the autoregressive coefficients. When the interval contains 1 we can conclude that the time series is a difference stationary

[3] Long memory unit root tests are an exception. These tests provide some information about the degree of persistence.

[4] The bootstrap methods started by Efron (1979) and has been employed widely in empirical and theoretical studies. See Efron and Tibshirani (1993) for an introduction of bootstrapping.

($I(1)$) process, and when the upper bound of the confidence interval is less than 1, the process will be trend stationary ($I(0)$). There are different types of bootstrap methods available in the literature to construct the confidence interval. Some authors have used the conventional bootstrapping, which takes samples with replacement of size n from the original sample of size n. Most of these approaches rely on the assumption of independent innovations. Yet other scholars such as Romano and Wolf (2001), propose another way of constructing confidence intervals based on taking samples without replacement, called a subsampling bootstrap or simply subsampling. The novelty of this approach is that unlike the conventional bootstrapping techniques, it can successfully handle the innovations that exhibit long memory process or have discontinuities[5]. In addition, these procedures require very weak assumptions and they can even be applied for dependent innovations. Moreover, they have good finite sample properties.[6]

The benefits of using subsampling bootstrap confidence intervals to examine the existence of a unit root or the persistence degree of a time series are multifold. First, confidence intervals are much more informative than the point estimates, such as the unit root tests.[7] Second, the confidence interval could be constructed in such a way that the results be robust to the presence of a root on or near the unit circle.[8] Third, it does not require validity of Gaussian assumptions regarding estimates of the coefficients and it provides more accurate results even in finite samples. Fourth, subsampling method outperforms the traditional tests even for the series that exhibit long memory (Pilar, 2005; Andrews and Lieberman, 2006, among others). Furthermore, it is shown that the subsampling confidence intervals are more reliable than the confidence intervals that are constructed based on the asymptotic theory. In sum, the results from subsampling confidence intervals can provide more

[5]The presence of a unit root in time series is considered as one of the cases that causes discontinuity in the limiting distribution of estimators.

[6]It is a very important advantage, especially in our research project that uses annual data and the number of observations is limited.

[7]For example, it shows the variation range of the measured degree of persistence. Furthermore, the lower bound of the confidence interval indicates the minimum degree of persistence of the time series.

[8]It is well known that the unit root tests suffer from the power loss when the time series has a root close to the unit circle (see Maddala and Kim, 1998).

reliable information to policy makers and will thereby help them in designing appropriate policies.

The integration property of EN has been studied in many papers; however, the results are mixed, depending on the data and econometric techniques employed.[9] Altinay and Karagol (2004) examined the EN data from Turkey over the period 1950-2000 and showed that these data appear to be stationary. Lise and van Montfort (2007) studied the stationarity property of the EN in Turkey during 1970-2003 and showed that the EN is non-stationary. Soytas and Sari (2003) arrived to the same conclusion for Turkey. Recently, Aslan and Kum (2011) studied the integration property of EN for Turkish disaggregated data for the period 1970-2006. Using linear and non-linear unit root tests they concluded that the ENs in different sectors have different integration orders. Zamani (2007) and Lotfalipour *et al.* (2010) examined the EN in Iran and found that the series is integrated of order one.

Yoo (2006) investigated the data from different Southeast Asian countries and demonstrated that the EN in these countries are not stationary. Lee and Chang (2008) used panel unit root tests to study the integration property of EN in 16 Asian countries and concluded that the EN in these countries are $I(1)$. Hsu *et al.* (2008) studied the stationarity of EN in 84 countries during 1971-2003. They used the panel seemingly unrelated ADF (Panel SURADF) unit root test, which allows for cross sectional effects. The results show that regional differences have a significant effect on the stationarity of EN. In addition, the results indicate that the EN in the U.S. is an integrated process. Narayan and Smyth (2007) studied the per-capita EN in 182 countries over the period 1979-2000. Applying univariate unit root tests, they showed only a third of the series are stationary. But, using the panel unit root test of Im *et al.* (2005) they found that the per-capita EN is stationary.

Chen and Lee (2007) employed data from 104 countries to examine the stationarity of per-capita EN. They divided these countries into seven groups and with the help of panel unit root tests they showed that the series are stationary. Lean and Smyth (2009) took a different approach and studied the long memory property in the U.S. disaggregated petroleum consumption.

[9] For a complete survey of the literature on the integration properties of EU see Smyth, 2013.

They used monthly data from 1973:1 to 2008:7 and showed the petroleum consumption in the commercial and industrial sectors is fractionally integrated, while the petroleum consumption in the residential sector follows a stationary process. Mishra *et al.* (2009) used the panel test of Carrio-i-Silvestre (2005) to examine the unit root properties of per-capita EN in 13 Pacific Island countries during 1980-2005. They provided evidence of stationarity for the panel of the countries under the study. In 2009, these authors used data from nine Pacific Island countries over the period 1980-2005 and concluded that the per-capita EN is non-stationary.

Apergis *et al.* (2010) used natural-gas consumption data for the 50 U.S. states during 1980-2007 to study the stationarity of the natural-gas consumption. The results from panel unit root and stationarity tests show that these series are integrated of order one. However, allowing for structural breaks changes the results and the series appear to be stationary. Recently, Narayan *et al.* (2010) studied the existence of a unit root in the sectoral EN for Australia and the Australian states. The results from the two-break unit root test of Lee and Strazicich (2003) show that the null hypothesis of non-stationarity can be rejected for most of the sectors. Fallahi (2011) using data from 1960-2005 showed that the EN in the U.S. is integrated and non-stationary. Joyeux and Ripple (2011) examined the EN for the 30 OECD and 26 non-OECD countries during 1960-2007. The results from panel unit root tests indicated strong evidence of non-stationarity for the total EN and also electricity consumption in these countries. Apergis and Tsoumas (2012) used the disaggregated fossils, coal, and electricity use in different sectors in the U.S. economy over 1989-2009 to examine the long memory properties of these variables. The results are in favor of stationarity of the EN in the sectors. Tang and Tan (2012) studied the relationship between electricity consumption and economic growth in Portugal. They have used ADF and multiple-break LM unit root tests proposed by Lee and Strazicich (2003, 2004) and concluded that the EN in Portugal is not stationary. Mohammadi and Parvaresh (2014) examined EN in a panel of 14 oil-exporting countries over 1980–2007 and with the help of panel unit root statistics, concluded that the EN in these countries is non-stationary.

As the provided literature review shows, there is no clear understanding about the stationarity of the EN. The integration property of the EN may vary under the influence of different factors. Abundance of energy resources, existence of environmental policies, and energy intensity are among the factors that might affect the stationarity or non-stationarity of the EN. In addition, the EN in a large (small) sector is more likely to be non-stationary (stationary) because shocks would create a greater (smaller) deviation from the long-run path (Hsu *et al.*, 2008).

This paper, to the best of our knowledge, is the first attempt to examine the stationarity of the EN using subsampling confidence intervals. To that end, we construct the 90% confidence intervals for the sum of the autoregressive coefficients[10]. We adapt the procedures that have been proposed by Romano and Wolf (2001). These approaches have a correct first-order asymptotic coverage in finite samples. We employ per capita EN data from 107 countries around the globe during 1971-2011. Our findings show that the per capita EN in 39 countries, i.e. 36% of our sample, are stationary. In fact, 61% of the OECD countries, 55% of the OPEC members, and 33% of the G20 countries appear to have stationary EN. In addition, the tightest confidence intervals are found for the Middle Eastern countries. With the help of these results we were able to classify countries in terms of their EN property as follows: with explosive behavior (highly populated with high-growth economies-4 countries); non-stationary (developing and highly oil dependent economies-64 countries); and stationary (generally developed and energy-rich countries-39 countries). An explosive behavior of EN would make government environmental related policies improbable as they require strict enforcement rules for the policy to be effective.

The remainder of this paper is organized as follows. The methodologies of constructing the confidence intervals are outlined in Section 2. In section 3, we report the data and the empirical findings of the paper. Finally, section 4 concludes.

[10] As stated in Romano and Wolf (2001), this parameter shows the long run persistence of the series.

2 Econometric Methodology

Any time-series process could be classified into two groups: non-stationary and stationary. A non-stationary variable has at least one root equal to 1 or -1 and any shock to this variable would have a permanent effect. But, for a stationary variable, the absolute values of all the roots are less than 1 and shocks will have a transitory effect on the variable. That is, the effects of these shocks will fade or decay over time. There are two main approaches to differentiate stationary time series variables from the non-stationary ones: unit root tests and confidence intervals. If we could reject the null of unit root hypothesis using any unit root test, we conclude that the series is stationary, $I(0)$. Alternatively, if the upper bound of the constructed confidence interval be smaller than 1, we call the series stationary.[11] However, if the upper bound of the confidence interval touches or exceeds 1, the series is considered non-stationary. This interval provides more information about the persistence of the time series compare to the unit root tests.

The confidence interval could be constructed for the largest coefficient ($\rho_{\max}$) in an $AR(p)$ model or for the sum of the coefficients (α). However, it is shown by Andrews and Chen (1994) and Rapach and Wohar (2004), that α provides more accurate information compared to the $\rho_{\max}$, because two $AR(p)$ models with an identical largest root could have different persistence properties.

Different methods are available to construct the confidence interval for α. The asymptotic 90% confidence interval can be constructed using the classic formula $\hat{\alpha} \pm 1.645 \times \sigma$, where σ shows the standard error. However, using this method is not appropriate when the absolute value of the root is near to 1. In addition, when the series under consideration has a unit root, the traditional asymptotic theory becomes discontinuous, and we cannot use this formula to construct the confidence interval (Torous et al., 2004). This is a serious issue as most of the economic variables seem to have a root close or equal to 1. Moreover, in a local to unity framework, the distribution of $t-$ratio depends on c, which makes this distribution a non-standard and non-pivotal

[11] For an integrated process, the sum of coefficients in an $AR(p)$ model equals unity; but, it is less than unity for a stationary process.

distribution.[12]

To overcome these problems Romano and Wolf (2001) proposed two alternative approaches for constructing the confidence intervals based on the subsampling method of Polities and Romano (1994). In these methods, the computed OLS estimators on subsamples or blocks of the observed data are used to obtain the distribution of the estimators. Next, the distribution of these subsample estimates is used to approximate the distribution of the entire sample. In these approaches, the assumptions of $i.i.d$ and normal residuals are not required.

These methods that are put forward by Romano and Wolf (2001) can be used even for the cases with a unit root or an explosive root, and they provide correct first-order asymptotic coverage. These approaches divide the observed data into different subsamples, or blocks, and compute the coefficients using the least square method. In addition, the t-statistic for α is calculated using $\sqrt{b}\left(\hat{\alpha}_{b,m}-\hat{\alpha}\right)/\hat{\sigma}_{b,m}$, where b shows the block size, $\hat{\alpha}_{b,m}$ is the OLS estimate of α for the mth block, $\hat{\sigma}_{b,m}=\sqrt{b}\times s.e\left(\hat{\alpha}_{b,m}\right)$, $s.e$ shows the standard error, and $m=1,2,...,T-b+1$.[13] Next, the following formula is used to get the approximate distribution of the subsample t-statistic

$$L_b(y)=(T-b+1)^{-1}\sum_{m=1}^{T-b+1}1\{\sqrt{b}\left(\hat{\alpha}_{b,m}-\hat{\alpha}\right))\leq y\}. \tag{1}$$

This approximation of subsampling distribution can be used to get the 90% two-sided equal-tailed confidence interval for α as following

$$[\hat{\alpha}-T^{-0.5}c_{b,0.950},\hat{\alpha}+T^{-0.5}c_{b,0.050}] \tag{2}$$

where $c_{b,0.950}$ and $c_{b,0.050}$ show the 0.95 and 0.05 quantiles of the subsampling distribution as approximated before. In addition, Romano and Wolf (2001)

[12] Furthermore, even though the construction of a confidence interval for sum of the $AR(p)$ coefficients can be based on the OLS estimation of the coefficients, the convergence rate and distribution type of these estimators differ for stationary and non-stationary cases. For a stationary case, the limiting distribution of the estimator is normal and its convergence rate is $\sqrt{T}$; whilst, for a non-stationary time series, the distribution is non-standard and the convergence rate is the sample size, T (Romano and Wolf, 2001).

[13] $\sqrt{b}$ is called the normalizing constant.

propose an alternative approach to construct the confidence interval called the two-sided symmetrical confidence interval. In order to obtain the symmetrical confidence interval instead of equation (1) the following equation is used to approximate the empirical distribution

$$L_{b,|.|}(y) = (T-b+1)^{-1} \sum_{m=1}^{T-b+1} 1\{\sqrt{b}\,|\hat{\alpha}_{b,m} - \hat{\alpha}|) \leq y\}. \tag{3}$$

If the quantiles from this approximate distribution is used, the constructed confidence interval is called the symmetric confidence interval.

Another issue that needs to be considered is the way that the subsample, or block, size is selected. To select the block size, Romano and Wolf (2001) propose an algorithm as follows.

First, compute the 90% confidence interval for α for each $b \in [b_{small}\ ,\ b_{big}]$ and denote the endpoints with $I_{b,low}$ and $I_{b,up}$.[14] Next, for every b calculate the standard deviation of the interval endpoints and select the value of b with the smallest standard deviation as the optimum block size, b^{*}, and report $[I_{b^{*},low},\ I_{b^{*},up}]$ as the final confidence interval for the α.[15]

3 Data and Empirical Results

This paper studies the persistence of per capita EN[16] of 107 countries.[17] Annual data over the period 1971-2011 are obtained from the World Development Indicators database published by the World Bank (2013) and converted into natural logarithms.

[14]Romano and Wolf (2001) recommend to set $b_{small} = c_1 T^{\eta}$ and $b_{big} = c_2 T^{\eta}$. Based on the simulation results, they suggest to consider $0.5 \leq c_1 \leq 1$ and $2 \leq c_2 \leq 3$ and $\eta = 0.5$.

[15]The choice of block size, b, plays a crucial role. Selecting a very small or very large b would result in a poor approximation of the actual distribution.

[16]Energy use refers to use of primary energy (kg of oil equivalent per capita) before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

[17]These countries are selected based on data availability and only those countries were included for which data were available from 1971 until 2011.

To provide information about the persistence degree of the EN, we construct the 90% confidence intervals[18] using the equal-tailed and symmetric subsampling approaches of Romano and Wolf (2001).[19]

The results from the equal-tailed and symmetric subsampling confidence intervals are reported in Table 1 and Table 2, respectively. The lag lengths (k^*) are selected using the Schwarz Bayesian criterion. The subsample size or block size was selected based on the algorithm proposed by Romano and Wolf (2001) with $b_{small} = 6$, and $b_{big} = 19$.[20]

Based on the equal-tailed subsampling approach the upper bound of the confidence interval of 22 countries are lower than 1; therefore, the EN in these countries do not have a unit root and they are stationary. However, the lower bounds of the estimated confidence intervals for Mozambique, Norway, and Tunisia are greater than 0.9, which show that even though the EN in these countries are stationary, they are very persistent and any shock to these series would last a long time. Another point worth noting is that the lower bounds for Argentina, Bangladesh, Cameroon, Chile, China, India, Nepal, Sri Lanka and Vietnam are higher than unity, so the evidence on the non-stationarity of the EN in these countries are stronger and it exhibits an explosive pattern.

As an alternative approach, we construct the confidence interval for the sum of the $AR(p)$ coefficients using the symmetric subsampling approach of Romano and Wolf (2001), which are presented in Table 2.

Symmetric confidence intervals have improved coverage accuracy (Beran, 1987; Hall, 1988; Romano and Wolf, 2001), are also tighter than equal-tailed ones (Hall, 1988), and finally as Romano and Wolf (2001) have shown these type of confidence intervals are able to cope with some mild misspecifications in residual autocorrelation. In addition, Mikusheva (2007) have shown that the subsampling symmetric approach of Romano and Wolf (2001) has a better performance compare with the subsampling equal-tailed procedure of Romano and Wolf (2001); hence, we base our conclusions solely on the

[18] We also constructed the 95% confidence intervals and presented the results in Appendix A (Table A-1).

[19] The subsampling equal-tailed and symmetric confidence intervals are estimated using the GAUSS code provided by David Rapach.

[20] Equivalently, we use $c_1 = 1$, $c_2 = 3$, and $\eta = 0.5$, as recommended by Romano and Wolf (2001).

results from the subsampling symmetric approach.

Table 2 classifies the countries in three categories: with stationary EN; non-stationary EN; and the EN with an explosive behavior. According to the estimated confidence intervals, the EN in 39 country is stationary. These countries are as follows: Algeria, Austria, Bahrain, Belgium, Bolivia, Brunei Darussalam, Canada, Columbia, Czech, Denmark, El Salvador, Finland, France, Ghana, Greece, Hungary, Iraq, Italy, Jamaica, South Korea, Libya, Luxemburg, Mexico, Mozambique, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Paraguay, Philippine, Qatar, Senegal, Spain, Sweden, Syria, Tunisia, USA, and Venezuela.[21]

Based on the data from the World Development Indicators database, 17 of these countries are energy exporters[22] and the rest, 22 countries, are net energy importers. Also, according to Table 3 in the countries that are included in this study, all North American countries and 52% of the European countries have stationary EN.[23] These constructed 90% confidence intervals are shown in Figure 1. As it can be seen from Figure 1, the lower bound of the calculated confidence intervals in 17 Asian countries and eight Middle Eastern countries are higher than 0.8. In fact, 85% of Asian, 73% of the Middle Eastern, 63% of African, and 62% of Central/South American countries have a lower bound larger than 0.8; while, it is 46% in Europe and only 33% in the North America.[24]

Therefore, the findings indicate that the EN are highly persistent, especially in Asia and Middle East. Moreover, the tightest confidence intervals are found for the Middle Eastern countries. Based on these results 61% of

[21] We also calculated the 95% confidence intervals based on the subsampling symmetric approach, the results remained the same for most but not all countries. According to the 95% confidence intervals, the EN in Austria, Belgium, Canada, Columbia, Czech, Italy, Spain, and Syria are integrated. These results are presented in Table A1 in the appendix A.

[22] These countries are Algeria, Bahrain, Bolivia, Brunei Darussalam, Canada, Columbia, Denmark, Iraq, Libya, Mexico, Mozambique, Nigeria, Norway, Paraguay, Qatar, Syria, and Venezuela.

[23] Increased use of renewable energy, due to environmental laws, or improved energy efficiencies might be considered as a potential factor that makes the energy use in these countries stationary.

[24] Recall that the lower bound shows the lowest degree of persistence.

the OECD countries, 55% of the OPEC members, and 33% of the G20 countries appear to have stationary EN; therefore, we can say that most of the developed and energy-rich countries have a stationary EN.

There are several points worth highlighting about these findings. First, for 21 countries the results from equal-tailed and symmetric approaches are the same and both show that the EN in these 21 country is stationary. Second, even though the EN in South Korea, Mozambique, Tunisia, and Spain are stationary, they are very persistent because the lower bound of the estimated confidence interval for these four countries are larger than 0.9. Third, the class of nonstationary series (the largest class) comprises 64 countries[25] and in this class we see developing countries as well as countries with highly oil-dependent economies. Finally, the class of countries with a nonstationary and explosive behavior, which includes Bangladesh, China, India and Vietnam. Further investigation of the EN in these four countries indicate that the EN in Bangladesh, China, and India were increasing smoothly, and it was increasing in Bangladesh from 1976 onward. At the same time, according to EIA report, China is the largest and India is the fourth largest energy consumer in the world and their economy is growing in a rapid pace which increases their need for energy; therefore, the behavior of EN in these two countries could be different from the rest. As for Vietnam, the country's rapid economic growth, industrialization, and export market expansion have raised EN in this country constantly (EIA, 2013).

In sum, in the countries that the EN found to be stationary, the energy conservation[26] or demand-management policies would have a temporary effect. In addition, any undesirable deviation in the EN of these countries, due to geopolitical or economic policies, requires no intervention of government. At the same time, in 64 of the 107 countries that have been studied in this

[25] These countries are Albania, Angola, Argentina, Australia, Benin, Brazil, Bulgaria, Cameroon, Chile, Congo Democratic Republic, Congo Republic, Costa Rica, Cote d'Ivoire, Cuba, Cyprus, Dominican Republic, Ecuador, Egypt, Ethiopia, Gabon, Germany, Guatemala, Haiti, Honduras, Hong Kong, Iceland, Indonesia, Iran, Ireland, Japan, Jordan, Kenya, North Korea, Lebanon, Malaysia, Malta, Morocco, Myanmar, Nepal, Oman, Pakistan, Panama, Peru, Poland, Portugal, Romania, Saudi Arabia, Singapore, Slovakia, South Africa, Sri Lanka, Sudan, Switzerland, Tanzania, Thailand, Togo, Trinidad and Tobago, Turkey, USE, UK, Uruguay, Yemen, Zambia, and Zimbabwe.

[26] To cut the emission of the greenhouse gases, for example.

paper, shocks to the EN would create permanent deviations and government interventions are needed to correct the deviations, if these deviations are found to be undesirable. In other words, in these countries, economic or environmental-oriented policies would be useful to alter the EN. For the 4 countries with explosive behavior, government environmental related policies are improbable as they require strict enforcement rules for the policy to be effective.

4 Conclusion

In this paper, we examined stationarity properties of per capita energy use (EN) across 107 countries around the world during 1971-2011. To that end, we used two subsampling techniques, proposed by Romano and Wolf (2001), to construct the 90% confidence intervals for the sum of the coefficients (α) in an $AR(p)$ model. These approaches have, to the best of our knowledge, never been used before to study the stationarity and persistence degree of EN. These confidence intervals provide more information compared to the point estimates, such as the unit root tests, and they also can be constructed in such a way that the results be robust to the presence of a root on or near the unit circle.

With the help of these results we were able to classify countries in terms of their EN property as follows: with explosive behavior (highly populated with high-growth economies- 4 countries); non-stationary (developing and highly oil dependent economies- 64 countries); and stationary (generally developed and energy-rich countries- 39 countries).

In terms of policy implications, for the countries where we found that the EN is stationary (39 countries), any shock to the EN would have a transitory effect, policies such as energy conservation and demand-side management would not be effective in modifying the EN in these countries. These findings have some implications for environmental protection authorities as well, in the countries with a stationary EN, it is not effective to use EN controls as a tool to protect the environment. Another implication of these findings are rather technical, which indicates that the past trend of the EN can be used to forecast the future EN in these 39 country. And the econometric models which deal with these time-series must use them in levels and no differencing is necessary.

Different factors might influence the integration property of EN. Abundance of energy resources, existence of environmental policies and energy intensity are among the factors that might affect the stationarity or non-stationarity of the EN.

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Table 1: The 90% confidences intervals constructed using equal-tailed approach

	k*			k*			k*			k*	
Albania	1	(0.849, 1.072)	Dominican	1	(0.817, 1.097)	North Korea	3	(0.942, 1.072)	Saudi Arabia	1	(0.950, 1.067)
Algeria	1	(0.873, 1.028)	Ecuador	1	(0.886, 1.057)	South Korea	1	(0.952, 1.004)	**Senegal**	1	(0.863, 0.985)
Angola	1	(0.850, 1.119)	Egypt	1	(0.950, 1.069)	Lebanon	1	(0.860, 1.091)	Singapore	1	(0.911, 1.023)
Argentina	1	(1.013, 1.159)	El Salvador	1	(0.909, 1.044)	**Libya**	1	(0.801, 0.999)	Slovak	1	(0.855, 1.233)
Australia	1	(0.929, 1.072)	Ethiopia	1	(0.959, 1.066)	Luxembourg	2	(0.853, 1.006)	South Africa	1	(0.822, 1.015)
Austria	1	(0.915, 1.010)	Finland	1	(0.885, 1.008)	Malaysia	1	(0.965, 1.010)	Spain	1	(0.892, 1.039)
Bahrain	1	(0.148, 0.741)	**France**	1	(0.872, 0.993)	Malta	2	(0.874, 1.242)	*Sri Lanka*	1	(1.026, 1.125)
Bangladesh	2	(1.019, 1.066)	Gabon	1	(0.899, 1.244)	**Mexico**	1	(0.870, 0.979)	Sudan	3	(0.825, 1.070)
Belgium	1	(0.8186, 1.04)	Germany	1	(0.728, 1.105)	Morocco	1	(0.962, 1.053)	Sweden	1	(0.726, 1.021)
Benin	1	(0.583, 0.996)	**Ghana**	1	(0.751, 0.965)	**Mozambique**	1	(0.912, 0.973)	Switzerland	1	(0.819, 1.067)
Bolivia	1	(0.829, 1.022)	**Greece**	1	(0.867, 0.969)	Myanmar	2	(0.723, 1.161)	Syria	1	(0.906, 1.055)
Brazil	1	(0.931, 1.073)	Guatemala	1	(0.922, 1.190)	*Nepal*	1	(1.004, 1.112)	Tanzania	2	(0.936, 1.041)
Brunei	1	(0.812, 0.943)	Haiti	1	(0.824, 1.086)	**Netherlands**	1	(0.584, 0.790)	Thailand	2	(0.988, 1.033)
Bulgaria	1	(0.853, 1.134)	Honduras	1	(0.895, 1.109)	**New Zealand**	1	(0.891, 0.977)	Togo	1	(0.939, 1.135)
Cameroon	1	(1.005, 1.330)	Hong Kong	1	(0.905, 1.030)	**Nicaragua**	2	(0.405, 0.912)	Trinidad & Tobago	1	(0.992, 1.072)
Canada	2	(0.853, 1.021)	**Hungary**	1	(0.793, 0.886)	**Nigeria**	1	(0.823, 0.938)	**Tunisia**	2	(0.901, 0.980)
Chile	1	(1.007, 1.085)	Iceland	1	(0.971, 1.084)	**Norway**	2	(0.905, 0.961)	Turkey	1	(0.957, 1.051)
China	2	(1.010, 1.070)	*India*	1	(1.021, 1.060)	Oman	1	(0.887, 1.138)	UAE	1	(0.860, 1.110)
Colombia	1	(0.806, 0.951)	Indonesia	1	(0.971, 1.034)	Pakistan	1	(0.961, 1.022)	UK	1	(0.821, 1.329)
Congo Dem. Rep.	1	(0.981, 1.109)	Iran	2	(0.916, 1.025)	Panama	1	(0.904, 1.070)	*Uruguay*	1	(1.006, 1.151)
Congo Rep.	1	(0.871, 1.102)	**Iraq**	1	(0.847, 0.956)	Paraguay	1	(0.884, 1.067)	USA	2	(0.643, 1.040)
Costa Rica	1	(0.977, 1.054)	Ireland	1	(0.913, 1.068)	Peru	2	(0.908, 1.094)	Venezuela	1	(0.706, 0.971)
Cote d'Ivoire	1	(0.909, 1.162)	Italy	1	(0.890, 1.037)	**Philippines**	1	(0.575, 0.965)	*Vietnam*	1	(1.054, 1.160)
Cuba	2	(0.950, 1.088)	Jamaica	2	(0.819, 1.104)	Poland	1	(0.940, 1.181)	Yemen	1	(0.899, 1.036)
Cyprus	1	(0.888, 1.080)	Japan	1	(0.894, 1.046)	Portugal	1	(0.941, 1.015)	Zambia	1	(0.965, 1.069)
Czech	1	(0.746, 1.002)	Jordan	1	(0.891, 1.045)	Qatar	1	(0.690, 1.238)	Zimbabwe	1	(0.957, 1.082)
Denmark	1	(0.523, 0.748)	Kenya	1	(0.809, 1.129)	Romania	2	(0.969, 1.150)			

k* shows the selected lag length. Bold font shows that the energy use is stationary. Italic font indicates that the energy use has an explosive behavior.

Table 2: The 90% confidences intervals constructed using symmetric approach

	k*			k*			k*			k*	
Albania	1	(0.705, 1.139)	Dominican	1	(0.722, 1.032)	North Korea	3	(0.900, 1.048)	Saudi Arabia	1	(0.863, 1.037)
Algeria	1	(0.863, 0.955)	Ecuador	1	(0.802, 1.011)	**South Korea**	1	(0.955, 0.993)	**Senegal**	1	(0.861, 0.981)
Angola	1	(0.819, 1.060)	Egypt	1	(0.919, 1.020)	Lebanon	1	(0.751, 1.043)	Singapore	1	(0.834, 1.050)
Argentina	1	(0.862, 1.119)	**El Salvador**	1	(0.851, 0.986)	**Libya**	1	(0.728, 0.932)	Slovak	1	(0.780, 1.021)
Australia	1	(0.817, 1.030)	Ethiopia	1	(0.819, 1.051)	**Luxembourg**	2	(0.751, 0.949)	South Africa	1	(0.756, 1.008)
Austria	1	(0.874, 0.997)	**Finland**	1	(0.837, 0.980)	Malaysia	1	(0.956, 1.005)	**Spain**	1	(0.904, 0.970)
Bahrain	1	(0.055, 0.697)	**France**	1	(0.835, 0.973)	Malta	2	(0.773, 1.081)	Sri Lanka	1	(0.920, 1.114)
Bangladesh	2	(1.002, 1.059)	Gabon	1	(0.737, 1.127)	**Mexico**	1	(0.822, 0.941)	Sudan	3	(0.699, 1.044)
Belgium	1	(0.781, 0.998)	Germany	1	(0.619, 1.034)	Morocco	1	(0.938, 1.019)	**Sweden**	1	(0.600, 0.926)
Benin	1	(0.647, 1.040)	**Ghana**	1	(0.690, 0.963)	**Mozambique**	1	(0.909, 0.956)	Switzerland	1	(0.666, 1.034)
Bolivia	1	(0.824, 0.991)	**Greece**	1	(0.871, 0.957)	Myanmar	2	(0.516, 1.075)	**Syria**	1	(0.858, 0.995)
Brazil	1	(0.887, 1.060)	Guatemala	1	(0.882, 1.063)	Nepal	1	(0.985, 1.108)	Tanzania	2	(0.876, 1.035)
Brunei	1	(0.659, 0.882)	Haiti	1	(0.736, 1.004)	**Netherlands**	1	(0.594, 0.726)	Thailand	2	(0.972, 1.022)
Bulgaria	1	(0.748, 1.027)	Honduras	1	(0.730, 1.082)	**New Zealand**	1	(0.861, 0.977)	Togo	1	(0.875, 1.085)
Cameroon	1	(0.879, 1.248)	Hong Kong	1	(0.864, 1.016)	**Nicaragua**	2	(0.377, 0.834)	Trinidad & Tobago	1	(0.955, 1.072)
Canada	2	(0.670, 0.981)	**Hungary**	1	(0.752, 0.878)	**Nigeria**	1	(0.777, 0.926)	**Tunisia**	2	(0.910, 0.980)
Chile	1	(0.961, 1.072)	Iceland	1	(0.954, 1.049)	**Norway**	2	(0.859, 0.961)	Turkey	1	(0.937, 1.011)
China	2	(1.003, 1.054)	*India*	1	(1.011, 1.059)	Oman	1	(0.882, 1.050)	UAE	1	(0.826, 1.028)
Colombia	1	(0.803, 0.928)	Indonesia	1	(0.958, 1.012)	Pakistan	1	(0.957, 1.005)	UK	1	(0.718, 1.239)
Congo Dem. Rep.	1	(0.842, 1.102)	Iran	2	(0.900, 1.002)	Panama	1	(0.787, 1.017)	Uruguay	1	(0.834, 1.138)
Congo Rep.	1	(0.812, 1.059)	**Iraq**	1	(0.823, 0.955)	**Paraguay**	1	(0.831, 0.954)	**USA**	2	(0.571, 0.949)
Costa Rica	1	(0.937, 1.038)	Ireland	1	(0.901, 1.008)	Peru	2	(0.840, 1.064)	**Venezuela**	1	(0.537, 0.961)
Cote d'Ivoire	1	(0.740, 1.117)	**Italy**	1	(0.881, 0.974)	**Philippines**	1	(0.602, 0.942)	*Vietnam*	1	(1.018, 1.133)
Cuba	2	(0.743, 1.113)	**Jamaica**	2	(0.744, 0.985)	Poland	1	(0.815, 1.070)	Yemen	1	(0.803, 1.050)
Cyprus	1	(0.792, 1.073)	Japan	1	(0.820, 1.029)	Portugal	1	(0.925, 1.003)	Zambia	1	(0.884, 1.041)
Czech	1	(0.693, 0.988)	Jordan	1	(0.790, 1.025)	**Qatar**	1	(0.714, 0.927)	Zimbabwe	1	(0.874, 1.032)
Denmark	1	(0.448, 0.663)	Kenya	1	(0.656, 1.118)	Romania	2	(0.824, 1.084)			

k* shows the selected lag length. Bold font shows that the energy use is stationary. Italic font indicates that the energy use has an explosive behavior.

Table 3: List of stationary countries

Region	Number of countries included in the study	Number of stationary countries	Names of countries
North America	3	3	Canada, USA, Mexico
Central and South America	21	7	Bolivia, Columbia, El Salvador, Jamaica, Nicaragua, Paraguay, Venezuela
Europe	28	14	Austria, Belgium, Czech, Denmark, Finland, France, Greece, Hungary, Italy, Luxemburg, Netherland, Norway, Spain, Sweden
Middle East	11	4	Bahrain, Iraq, Qatar, Syria
Africa	24	7	Algeria, Ghana, Libya, Mozambique, Nigeria, Senegal, Tunisia
Asia and Oceania	20	4	Brunei Darussalam, S. Korea, New Zealand, Philippine
Total	107	39	

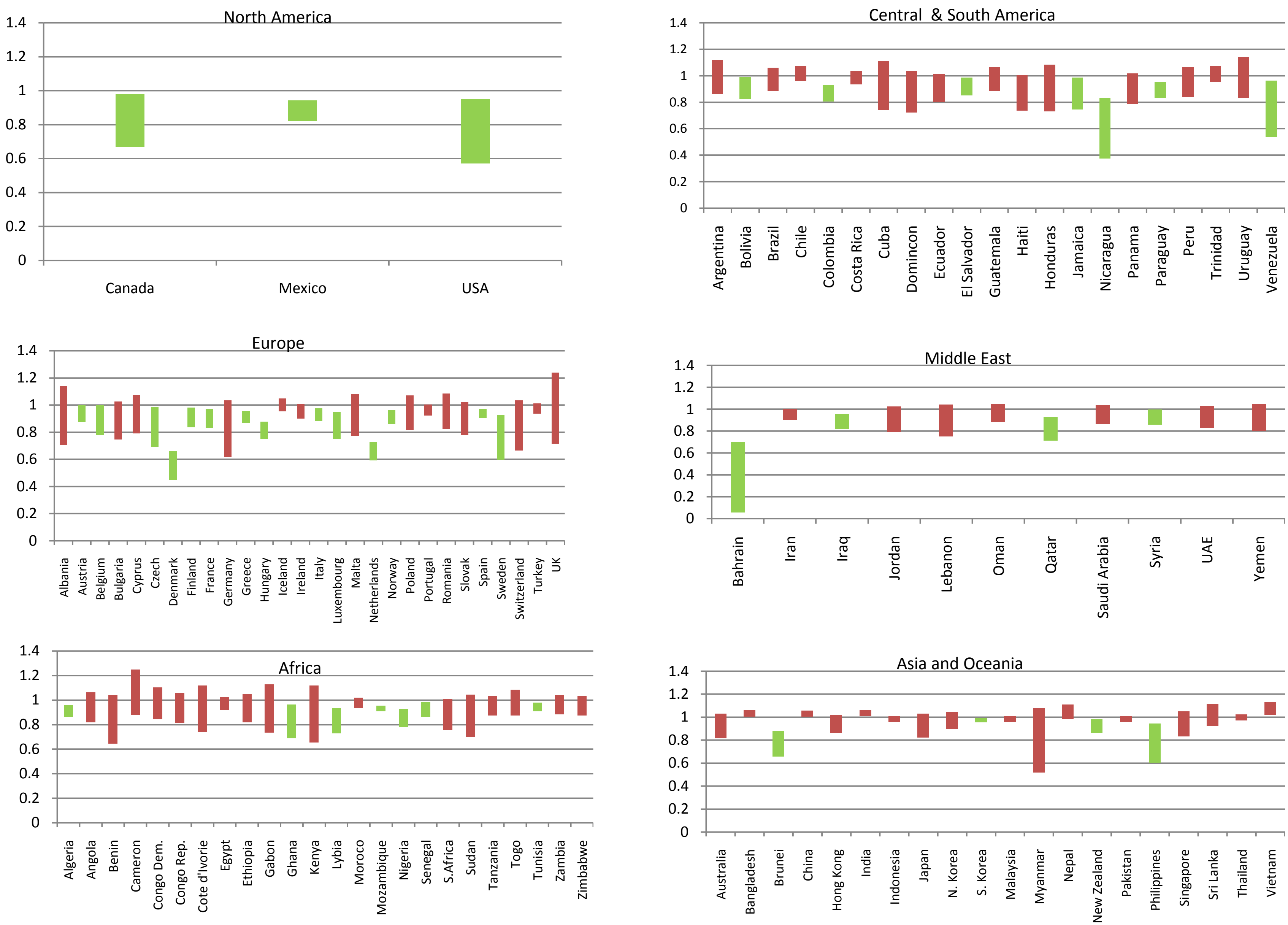

Figure 1: The calculated confidence intervals.
Countries with stationary energy use are shown in green.

Table A1: The 95% confidences intervals constructed using symmetric approach

	k*			k*			k*			k*	
Albania	1	(0.686, 1.158)	Dominican	1	(0.719, 1.035)	North Korea	3	(0.879, 1.070)	Saudi Arabia	1	(0.857, 1.042)
Algeria	1	(0.845, 0.972)	Ecuador	1	(0.764, 1.048)	**South Korea**	1	(0.950, 0.999)	**Senegal**	1	(0.860, 0.982)
Angola	1	(0.761, 1.118)	Egypt	1	(0.916, 1.023)	Lebanon	1	(0.719, 1.075)	Singapore	1	(0.862, 1.022)
Argentina	1	(0.827, 1.154)	**El Salvador**	1	(0.839, 0.998)	**Libya**	1	(0.677, 0.983)	Slovak	1	(0.753, 1.048)
Australia	1	(0.814, 1.033)	Ethiopia	1	(0.806, 1.064)	**Luxembourg**	2	(0.734, 0.966)	South Africa	1	(0.749, 1.015)
Austria	1	(0.869, 1.002)	**Finland**	1	(0.821, 0.996)	Malaysia	1	(0.944, 1.017)	Spain	1	(0.863, 1.011)
Bahrain	1	(0.000, 0.752)	**France**	1	(0.823, 0.986)	Malta	2	(0.778, 1.076)	Sri Lanka	1	(0.911, 1.123)
Bangladesh	2	(0.995, 1.066)	Gabon	1	(0.646, 1.218)	**Mexico**	1	(0.805, 0.959)	Sudan	3	(0.676, 1.066)
Belgium	1	(0.737, 1.041)	Germany	1	(0.595, 1.057)	Morocco	1	(0.921, 1.037)	**Sweden**	1	(0.572, 0.953)
Benin	1	(0.625, 1.062)	**Ghana**	1	(0.689, 0.964)	**Mozambique**	1	(0.903, 0.962)	Switzerland	1	(0.634, 1.065)
Bolivia	1	(0.819, 0.996)	**Greece**	1	(0.864, 0.964)	Myanmar	2	(0.453, 1.138)	Syria	1	(0.802, 1.051)
Brazil	1	(0.881, 1.067)	Guatemala	1	(0.866, 1.080)	Nepal	1	(0.983, 1.110)	Tanzania	2	(0.870, 1.041)
Brunei	1	(0.626, 0.914)	Haiti	1	(0.676, 1.064)	**Netherlands**	1	(0.448, 0.872)	Thailand	2	(0.964, 1.030)
Bulgaria	1	(0.707, 1.067)	Honduras	1	(0.715, 1.097)	**New Zealand**	1	(0.866, 0.972)	Togo	1	(0.850, 1.109)
Cameroon	1	(0.836, 1.291)	Hong Kong	1	(0.862, 1.017)	**Nicaragua**	2	(0.311, 0.899)	Trinidad & Tobago	1	(0.945, 1.082)
Canada	2	(0.637, 1.014)	**Hungary**	1	(0.747, 0.883)	**Nigeria**	1	(0.770, 0.933)	**Tunisia**	2	(0.903, 0.987)
Chile	1	(0.948, 1.084)	Iceland	1	(0.936, 1.068)	**Norway**	2	(0.828, 0.993)	Turkey	1	(0.931, 1.016)
China	2	(1.001, 1.056)	*India*	1	(1.009, 1.061)	Oman	1	(0.869, 1.062)	UAE	1	(0.808, 1.046)
Colombia	1	(0.682, 1.049)	Indonesia	1	(0.949, 1.021)	Pakistan	1	(0.954, 1.008)	UK	1	(0.641, 1.316)
Congo Dem. Rep.	1	(0.824, 1.120)	Iran	2	(0.872, 1.030)	Panama	1	(0.758, 1.045)	Uruguay	1	(0.826, 1.145)
Congo Rep.	1	(0.783, 1.088)	**Iraq**	1	(0.822, 0.956)	**Paraguay**	1	(0.808, 0.977)	**USA**	2	(0.559, 0.960)
Costa Rica	1	(0.927, 1.047)	Ireland	1	(0.859, 1.051)	Peru	2	(0.817, 1.087)	**Venezuela**	1	(0.527, 0.971)
Cote d'Ivoire	1	(0.711, 1.146)	Italy	1	(0.829, 1.026)	**Philippines**	1	(0.584, 0.960)	*Vietnam*	1	(1.023, 1.128)
Cuba	2	(0.772, 1.083)	**Jamaica**	2	(0.738, 0.991)	Poland	1	(0.799, 1.086)	Yemen	1	(0.804, 1.049)
Cyprus	1	(0.771, 1.094)	Japan	1	(0.814, 1.035)	Portugal	1	(0.919, 1.009)	Zambia	1	(0.870, 1.055)
Czech	1	(0.672, 1.008)	Jordan	1	(0.775, 1.040)	**Qatar**	1	(0.676, 0.966)	Zimbabwe	1	(0.862, 1.044)
Denmark	1	(0.396, 0.716)	Kenya	1	(0.645, 1.128)	Romania	2	(0.808, 1.100)			

k* shows the selected lag length. Bold font shows that the energy use is stationary. Italic font indicates that the energy use has an explosive behavior.