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Are shocks to electricity consumption transitory or permanent? Sub-national evidence from Turkey

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ABSTRACT

This is the first study that aims to investigate policy shocks to energy consumption in terms of unit root properties by sector. More precisely, we analyze the stationarity of electricity consumption for 12 regions of Turkey by four sectors in addition to total electricity consumption by region (for a total of 60 cases). We find that 48 cases are non-stationary and 12 cases are stationary. Thus, policies to decrease or stimulate the use of electricity have permanent effects on electricity consumption in 80% of the cases and transitory effects in the rest. Findings and policy implications are further discussed.

1. Introduction

Research on the stationarity of energy consumption has increased substantially over the past decade (Smyth, 2013; Smyth and Narayan, 2015). The stochastic behaviors of relevant variables are worth knowing for several reasons (Hasanov and Telatar, 2011). First, shocks to electricity consumption will have temporary effects if found to be stationary[1]. In the case of stationarity, government policies in this area may not be effective because innovations in the electricity sector may not have permanent impacts and electricity consumption will likely return to its original equilibrium level. Second, the non-stationarity of electricity consumption may alter the integration properties of some macroeconomic variables, such as interest rates, inflation rates, and GDP. Third, the stationarity of electricity consumption is important for estimating a reliable econometric model. In particular, a cointegration test must be used in when variables in a model are non-stationary because otherwise the coefficients of the independent variables become suspect. Finally, electricity consumption can be easily forecast if it is stationary; it cannot be easily forecast if it is non-stationary due to the stochastic nature of key factors.

Despite being an important subject for energy economics and having the attention of many studies, we see several limitations in the existing literature following Smyth (2013), and Smyth and Narayan (2015). First, the majority of studies consist of multi-country studies, which prevents researchers from investigating various disaggregated energy consumption by sector. Identifying heterogeneity across sectors is of central importance to policy makers since the stationarity of energy consumption factors may depend on the sector in which they are consumed. Even though many studies analyze single-countries, only a few consider stationarity properties by sector. Second, there is clearly a geographic toward the United States (U.S.); Smyth (2013) notes that 38% of single-country studies focus on the U.S. Furthermore, much of the existing literature considers aggregate energy consumption. Disaggregation has value because one form of energy consumption may contain a unit root whereas other forms of energy consumption may not contain a unit root[2]. Strategies proposed by policy

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[1] Shocks or sudden changes in consumption is related to socioeconomic, technological, and policy changes that affect prices or other key consumption factors.

[2] Referring to Wooldridge (2015), a *unit root* is a *feature* of *processes* that *evolve through time* that *can cause problems* in *statistical inference involving time series models.*

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makers should differentiate among types of energy consumption accordingly.

The last and prominent limitation in the literature is that only a small number of studies employ sub-national data. Exploring possible differences in energy use across regions within a country is important for at least two reasons. If energy consumption is found to be stationary in one region and non-stationary in another region, national policies to encourage or discourage energy consumption, taken as shocks to consumption, will have transitory and permanent effects in these regions, respectively. In this regard, governments may want to understand the reasons behind the heterogeneity across regions in order to apply different policies to each region. The use of regional data is of great utility. It takes into account several specificities and differences among regions, which allows for drawing more accurate conclusions and crafting more sustainable policies. Furthermore, it helps policy makers explore heterogeneity across sectors within a region, the heterogeneity for a specific sector across regions, and the heterogeneity across regions for a country.

In light of these considerations, this study contributes to the existing body of knowledge, both theoretical and practical, by empirically investigating unit root properties of electricity consumption for 12 regions of Turkey across four sectors in addition to total electricity consumption by region[3]. The investigation of electricity sector of Turkey is important to the literature because Turkey is the sixth largest consumer of electricity in Europe after Germany, France, the UK, Spain, and Italy (CIA World Factbook)[4]. Turkey is also an impressive country in regional and world affairs, a candidate country for the European Union, and a member of the G-20 countries.

To the best of our knowledge, this is the first time in the literature to investigate integration properties for a type of energy consumption by sector at the sub-national level. Karanfil (2009) asserts that policy makers care much more about the robustness and consistency of outcomes rather than time periods and econometric approaches employed in research studies. Because Smyth (2013) suggests the use of multiple unit root tests to make the results robust and consistent, we apply the Dickey-Fuller unit root test based on Generalized Least Squares regression, the Phillips-Perron unit root test, and the Zivot-Andrews unit root test with one endogenous structural break.

The rest of this study is as follow. The next section reflects on the state of the art, Section 3 describes the data and the methodology, Section 4 explores the results and compares them with the existing literature, and the last section concludes with findings and policy implications.

2. Literature review

A number of research studies have investigated the stationarity of energy consumption and related factors (Narayan and Smyth, 2007; Chen and Lee, 2007; Narayan et al., 2008; Lean and Smyth, 2009; Gil-Alana et al., 2010; Apergis and Tsoumas, 2011; Ozturk and Aslan, 2011; Lean and Smyth, 2013; Barros et al., 2013; Shahbaz et al., 2014; Yilanci and Tunali, 2014). Starting with studies focusing on national data, Narayan and Smyth (2007), applying Augmented Dickey-Fuller unit root test (ADF) to annual data, revealed that energy consumption is stationary in 31% of 182 countries. Chen and Lee (2007) found that energy consumption is stationary based on a panel study of 104 countries that employed panel unit root tests with structural breaks. Narayan et al. (2008) found evidence of mixed order of integration for crude oil consumption based on a panel of 60 countries and using several panel unit root tests without structural breaks (although their model did not contain a unit root after the authors accounted for possible structural breaks in their time-series). For a panel of 13 Pacific Island Countries, Mishra et al. (2009) provided evidence of mixed order of integration for energy consumption, employing stationarity tests without structural breaks; however, energy consumption was found to be stationary once the possibility of breaks was considered. Apergis and Tsoumas (2011) investigated integration properties related to the consumption of disaggregated solar, geothermal, and biomass for the U.S. by sectors, and noted that stationarity properties depend on the type of energy and vary by sector when using fractional unit root tests with and without structural breaks. By applying LM univariate unit root tests with up to two structural breaks to the Turkish sectoral data at national level, Ozturk and Aslan (2011) found that energy consumption includes no unit root in all sectors. Lean and Smyth (2013) show that the production of renewable energy, biofuels, and biomass for the U.S. are integrated of order one based on the LM univariate unit root tests with up to two structural breaks. Regarding natural gas consumption for a total of 43 countries, Shahbaz et al. (2014) revealed that the null hypothesis for the unit root test can be rejected for nearly 40% of these countries. Yilanci and Tunali (2014), using Fourier LM unit root test with structural breaks, showed that shocks to aggregate energy consumption are transitory in only 26 of 109 countries.

A small number of studies found in the literature use sub-national data. We are aware of only five that used sub-national data to investigate the integration properties of energy variables; surprisingly, four are based on U.S. data and one uses Australian sub-national data. Apergis and Payne (2010), using two different unit root tests with endogenously determined structural breaks, concluded that petroleum consumption is stationary in the majority of U.S. states. Narayan et al. (2010) found mixed evidence by applying stationarity tests with structural breaks as they investigated unit root properties of energy consumption for Australian states across nine sectors. Apergis et al. (2010a) showed that shocks to coal consumption are temporary based on a panel study of U.S. states where they applied several panel unit root tests with structural breaks. Apergis et al. (2010b) analyzed integration properties of natural gas consumption for U.S. states by employing several panel stationarity tests with and without structural breaks, claiming that the time-series data become stationary once structural changes are considered. Also looking at natural gas consumption, Aslan (2011) found that the null hypothesis regarding a unit root can be rejected for only 23 of the 50 U.S. states.

3. Data and methods

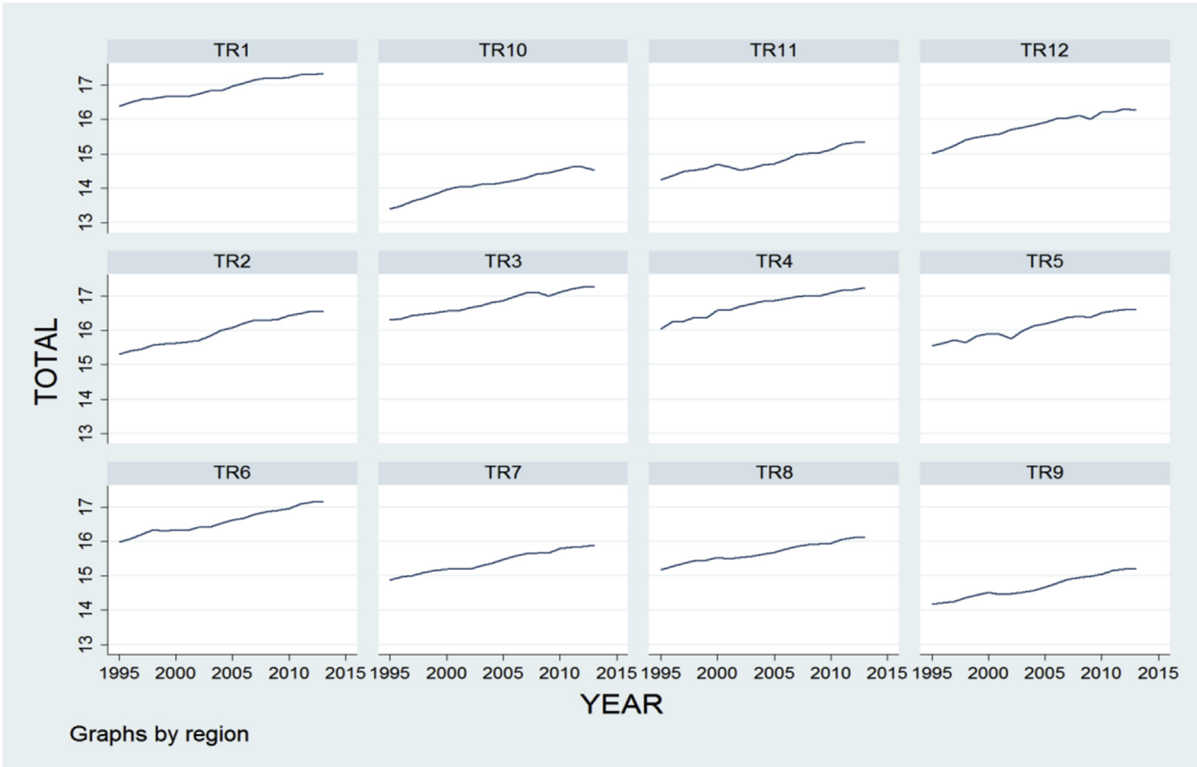
The annual data on electricity consumption by sector for 12 regions of Turkey were obtained from the Turkish Statistical Institute (www.turkstat.gov.tr)[5]. The data are from 1995-2013[6]. These sectors considered are industrial (IND), business (BUS), agriculture (AGR), and residential (RES) in addition to total electricity consumption (TOT). The regions are denoted by TR1 (Istanbul), TR2 (West Marmara), TR3 (Aegean), TR4 (East Marmara), TR5 (West Anatolia), TR6 (Mediterranean), TR7 (Central Anatolia), TR8 (West Black Sea), TR9 (East Black Sea), TR10 (Northeast Anatolia), TR11

[3] Regions and sectors are formed by the Turkish Statistical Institute.

[4] Please use the URL for an online version of the World Factbook https://www.cia.gov/.

[5] Construction and public buildings are not included in this study due to data unavailability. The database used here can be provided upon request for those who find it difficult to download the data from the source.

[6] These data are not available prior to 1995.



Graph 1. Time-series plot for total electricity consumption by region.

(Central East Anatolia), and TR12 (Southeast Anatolia). Descriptive statistics are presented in the Appendix. We convert the data into logarithmic form. Electricity consumption for the 12 regions of Turkey by the five sectors is given in Graphs 1–5. With regard to the data, we note first that the time series mostly show an increasing trend in electricity consumption by sector at the sub-national level, and second that structural breaks occur in almost all of the time series data.

This study first employs the Dickey-Fuller unit root test based on Generalized Least Squares regression (DFGLS), according to Elliott et al. (1996), so as to investigate integration properties of TOT, IND, BUS, AGR and RES for each region. It takes the following form:

$$\Delta y_t = \alpha + \beta y_{t-1} + \rho T + \sum_{i=1}^{n} \theta_i \Delta y_{t-i} + \varepsilon_t \tag{1}$$

where errors (ε_t) are independent and identically distributed, and Δ is lagged operator, and α and T are constant and time trend, respectively. H_o: $\beta=0$ and H_a: $\beta<0$, such that the null hypothesis of unit roots is tested against the alternative hypothesis of trend stationary. In this test, the lagged first-differenced terms Δy_{t-i}, are used to eliminate potential autocorrelation.

An alternative unit root test for DFGLS, attributable to Phillips and Perron (1988), is also used in this study. The PP is similar but more robust compared to the Dickey-Fuller test because the former handles serial correlation and heteroscedasticity in error terms by following Newey-West approach. The Phillips-Perron (PP) unit root test can be tested as:

$$\Delta y_t = \alpha + \beta y_{t-1} + \rho T + \varepsilon_t \tag{2}$$

where errors (ε_t) are assumed to be integrated of order one, Δ is lagged operator, and α and T are the constant and time trend, respectively. The null and alternative hypotheses are set as H_o: $\beta=0$ and H_a: $\beta<0$. In other words, the null hypothesis of non-stationarity is tested over the alternative hypothesis of trend stationarity.

Structural change may appear in time series data owing to socioeconomic, technological, or policy changes related to electricity consumption (as well as production). It may appear, for example, due to an economic crises leading to a price surge. Although the two mentioned tests are widely accepted and applied in the literature, their reliability decreases when time series data contain any structural breaks. To consider the possible existence of structural breaks in time series and strengthen the inference of our study, we adopt the Zivot-Andrews unit root test with one break (ZA), in which the structural break is endogenously determined from the data (Zivot and Andrews, 2002). The regression of the ZA is written by:

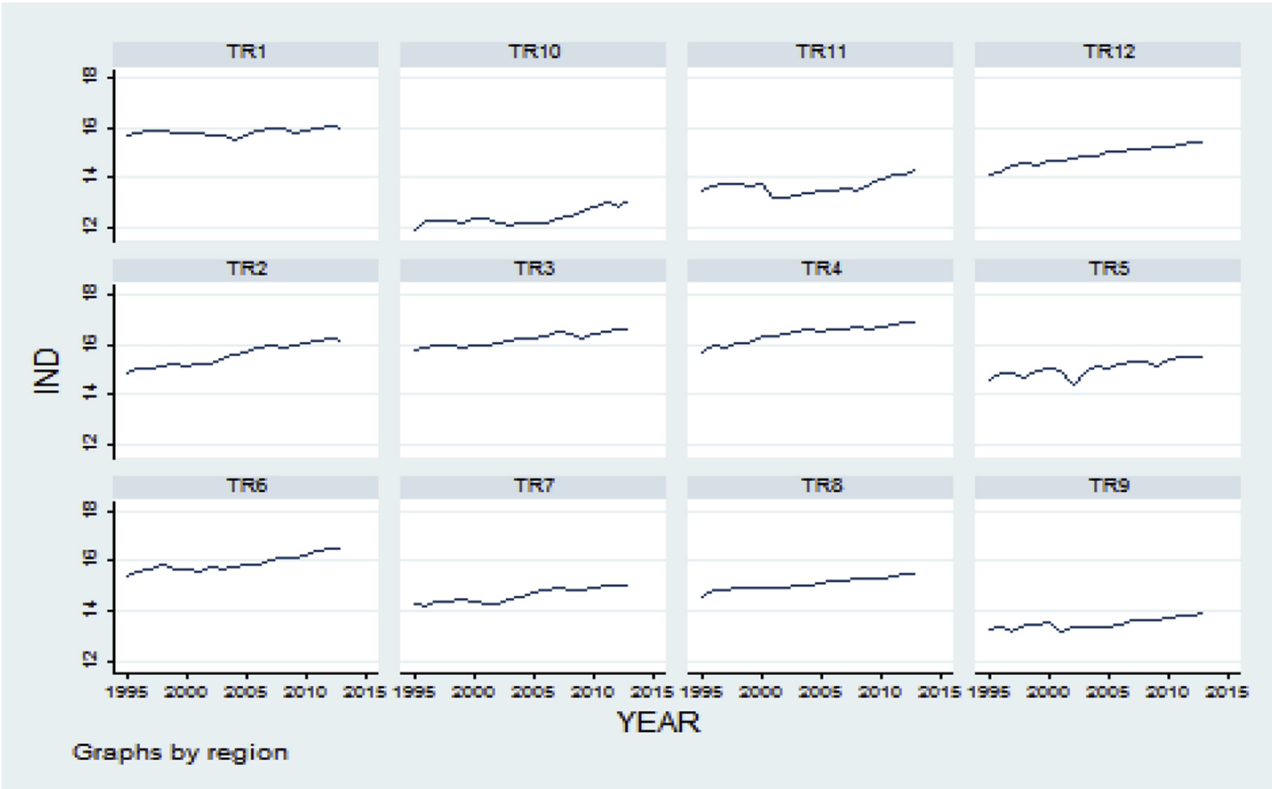
$$\Delta y_t = \alpha + \beta y_{t-1} + \rho T + \delta DM_t + \Phi DT_t + \sum_{i=1}^{n} \theta_i \Delta y_{t-i} + \varepsilon_t \tag{3}$$

where ε_t is a white noise residual; DM is a dummy variable for one-time change in intercept and DT is a dummy variable for a break in trend. These dummy variables are determined by the following method in which BD is the break-date.

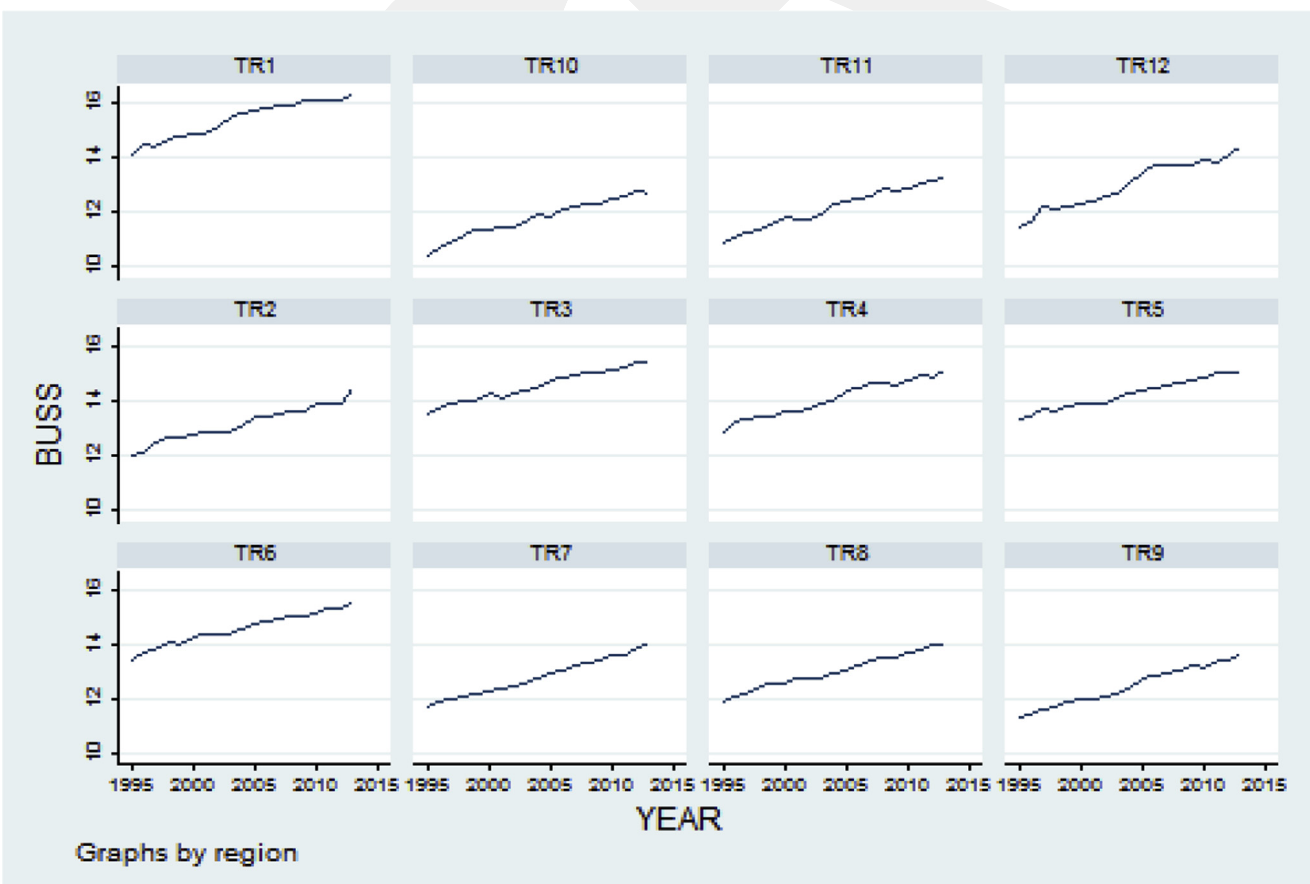
$DM = \begin{cases} 1\ldots if\ t > BD \\ 0\ldots otherwise \end{cases}$, and $DT = \begin{cases} t - BD\ldots if\ t > BD \\ 0\ldots\ldots\ldots\ otherwise \end{cases}$. The null hypothesis of non-stationarity is tested against the alternative hypothesis of trend stationarity through H_o: $\beta=0$ and H_a: $\beta<0$. Because the time period is not very long, the application of a unit root test with two structural breaks is unnecessary.

4. Results and discussions

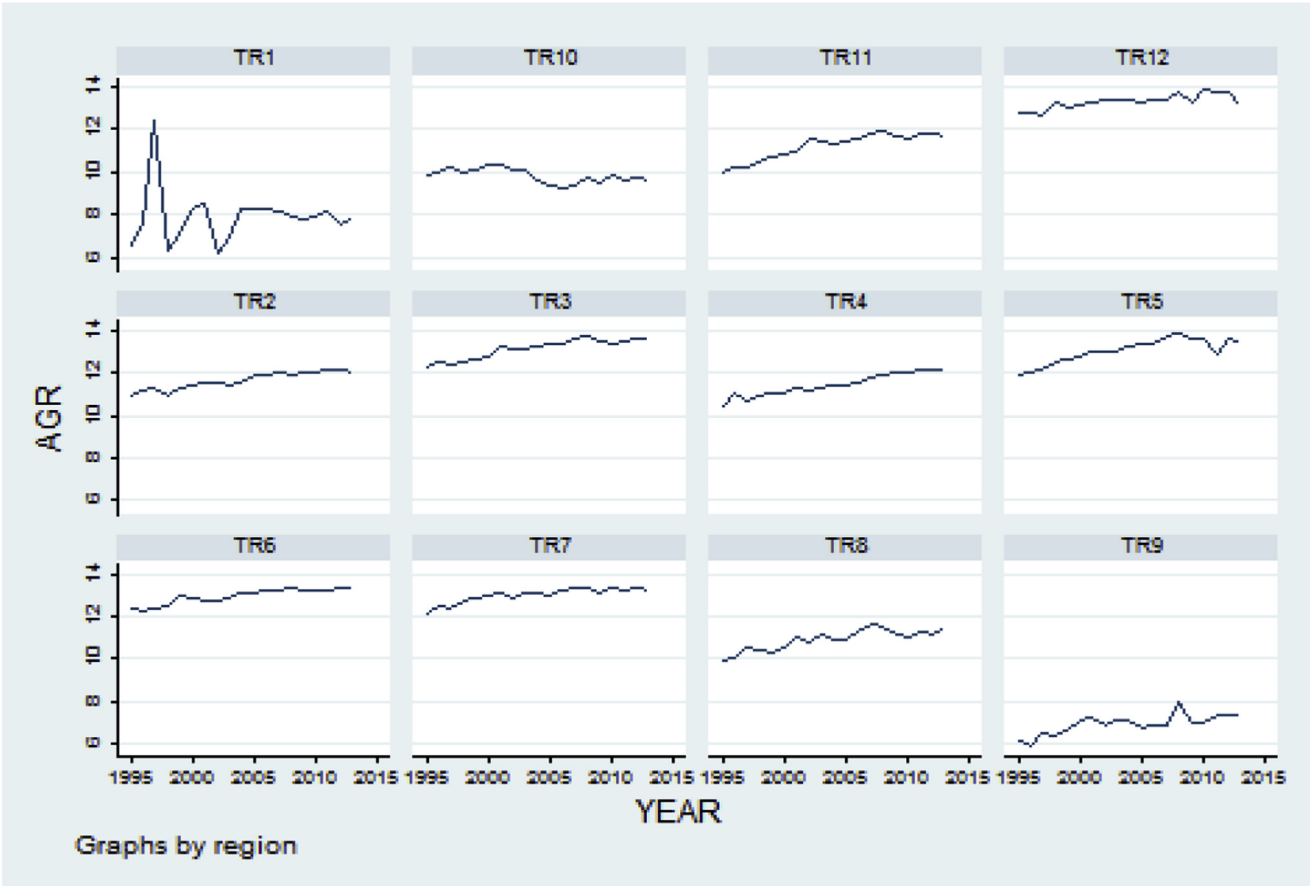
We apply the DFGLS, the PP, and the ZA unit root tests to



Graph 2. Time-series plot for electricity consumption in the industrial sector by region.



Graph 3. Time-series plot for electricity consumption in the business sector by region.

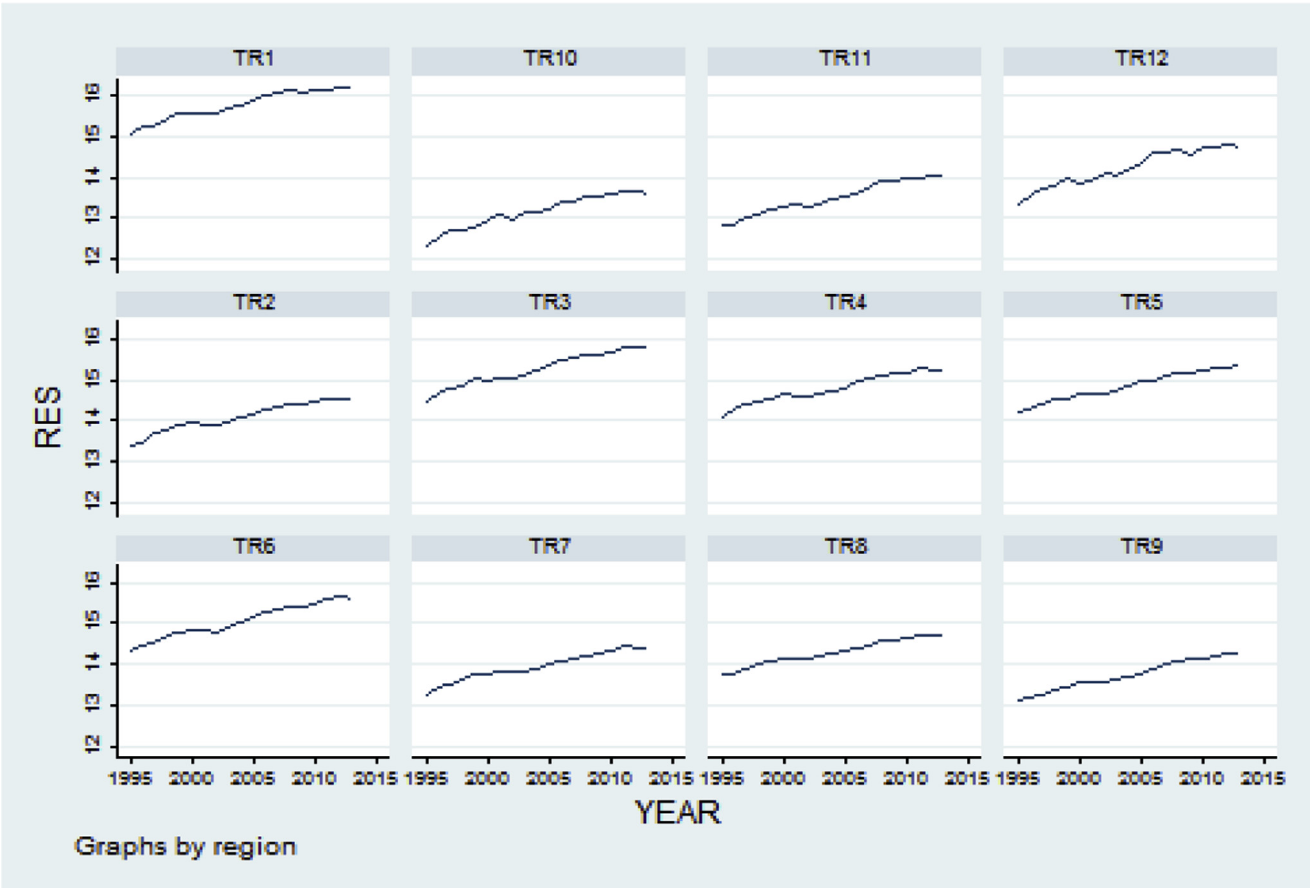


Graph 4. Time-series plot for electricity consumption in the agriculture sector by region.

electricity consumption by sectors for 12 regions of Turkey in order to examine their integration properties. It is useful to explore the heterogeneity across sectors within a region, the heterogeneity for a specific sector across regions, and the heterogeneity across regions for Turkey. Table 1 reports the integration properties of 60 cases (5 sectors, including total electricity consumption, across 12 regions). Columns one and two show the regions and the sectors, respectively. Columns three, four, and five indicate the test statistics from Equations 1, 2, And 3, respectively. The last column is the break date endogenously determined from the Zivot-Andrews unit root test in Equation (3). The null hypothesis of non-stationarity can be rejected in favor of the alternative hypothesis of stationarity at the 5% significance level only if the absolute value of test statistic is greater than the absolute value of critical values for 5% level. It should be noted that the 5% critical points are different for each unit root test. The DFGLS suggests that we can reject the null hypothesis for the agriculture sector in TR1, TR4, and TR12; for the industrial sector in TR5 and TR12; for the business sector in TR6 and for the residential sector in TR9. Shocks to electricity consumption have permanent effects on the rest. The Phillips-Perron unit root test reveals stationarity for the agriculture sector in TR1, TR4 and TR12; the industrial sector for TR5 and TR12; the business sector for TR6; and the residential sector for TR7. In short, national policies to encourage or discourage electricity consumption appear to have transitory effects in some sectors and regions only. These outcomes are virtually the same across the DFGLS and the PP unit root tests.

According to our results from the Zivot-Andrews unit root test with one structural break, electricity consumption is found to be stationary (integrated of order zero) for the agriculture sector in TR1, TR4, and TR7; for the industrial sector in TR5, TR8, TR9, TR10, and TR11; for the business sector in TR4, TR7, and TR9; and total electricity consumption in TR11. Policies to change the use of electricity consumption are thus expected to have only temporary effects in these cases. Shocks to electricity consumption have permanent effects in the rest of 60 cases. Once we take into account the structural change in the data, the number of stationary time-series results increases from seven to twelve (20%, of our cases). Considering the break dates in Table 1, each year reflects different events. A nationwide economic crisis affected Turkey in 2001. In line with electricity market liberalization, in 2001 the sector was divided into four different companies responsible for generation, transmission, distribution, and wholesale services. The nationwide electricity distribution network was divided into twenty-one regions in 2004 with implementation of the electricity market privatization law. A global economic crisis originating in the U.S. expanded across the globe beginning in 2008.

The increase in the number of stationary cases when we consider the structural break is in line with finding of the existing literature (Altinay and Karagol, 2004; Narayan et al., 2008; Mishra et al., 2009; Apergis et al., 2010b; Agnolucci and Venn, 2011; Ozturk and Aslan, 2011; Lean and Smyth, 2014). Furthermore, some sectors in some regions may appear to have a unit root because it is expected that not every region will respond to shocks in the same way. These findings are consistent with the existing studies. For instance, Narayan et al. (2010) investigate stationarity properties of energy consumption for Australian states for nine sectors and find mixed evidence. Aslan (2011) confirmed stationarity in natural gas consumption for only twenty-three of fifty U.S. states.



Graph 5. Time-series plot for electricity consumption in the residential sector by region.

Table 1
Unit roots tests results.

Reg.	Sector	DFGLS	PP	ZA		Reg.	Sector	DFGLS	PP	ZA	
TR1	TOT	−1.93	−1.99	−3.72	2005	TR7	TOT	−2.16	−2.17	−3.60	2005
	IND	−2.17	−2.13	−4.15	2006		IND	−2.84	−2.08	−4.22	2005
	BUS	−1.16	−1.66	−4.09	2003		BUS	−2.24	−2.09	−5.5*	2005
	AGR	−5.6*	−5.3*	−10.2*	2005		AGR	−3.24	−3.21	−5.4*	2001
	RES	−2.62	−1.89	−4.71	2008		RES	−3.42	−3.7*	−2.37	2002
TR2	TOT	−1.66	−1.72	−3.05	2006	TR8	TOT	−2.37	−2.56	−4.02	2001
	IND	−2.00	−1.98	−4.25	2004		IND	−2.96	−3.27	−7.2*	2001
	BUS	−3.08	−2.82	−2.86	2005		BUS	−2.74	−2.69	−3.46	2002
	AGR	−3.23	−2.90	−4.14	2005		AGR	−2.64	−2.46	−4.16	2009
	RES	−2.17	−2.05	−4.57	2007		RES	−2.90	−1.85	−4.42	2008
TR3	TOT	−2.69	−2.49	−4.93	2006	TR9	TOT	−2.35	−1.93	−4.76	2001
	IND	−3.23	−2.98	−4.00	2006		IND	−2.86	−2.69	−6.4*	2001
	BUS	−3.15	−3.08	−4.47	2005		BUS	−2.45	−2.39	−5.1*	2005
	AGR	−2.06	−1.81	−4.28	2001		AGR	−3.56	−3.32	−4.74	2002
	RES	−2.14	−2.04	−3.64	2010		RES	−4.1*	−1.90	−4.46	2010
TR4	TOT	−0.82	−3.10	−4.05	2003	TR10	TOT	−1.42	−0.92	−1.58	2010
	IND	−1.49	−3.10	−3.10	2000		IND	−1.57	−1.49	−5.1*	2007
	BUS	−3.34	−3.35	−5.7*	2005		BUS	−3.36	−3.09	−4.15	2000
	AGR	−5.9*	−5.6*	−12.4*	2008		AGR	−2.40	−2.29	−3.76	2004
	RES	−2.66	−2.71	−4.09	2006		RES	−2.52	−1.83	−3.97	2010
TR5	TOT	−3.31	−3.06	−4.22	2004	TR11	TOT	−2.50	−1.80	−5.3*	2001
	IND	−3.6*	−3.3*	−5.1*	2002		IND	−1.16	−0.87	−5.4*	2001
	BUS	−3.22	−2.99	−3.53	2004		BUS	−2.70	−2.46	−4.82	2006
	AGR	−2.20	−1.83	−3.75	2008		AGR	−1.62	−0.87	−3.37	2002
	RES	−2.24	−2.05	−4.32	2007		RES	−2.87	−2.08	−3.13	2007
TR6	TOT	−2.18	−2.21	−3.68	1999	TR12	TOT	−1.65	−1.98	−3.39	2009
	IND	−1.68	−1.64	−3.93	2003		IND	−3.7*	−4.2*	−4.62	1999
	BUS	−3.6*	−4.3*	−4.32	2009		BUS	−2.24	−2.30	−3.87	2005
	AGR	−2.27	−2.15	−5.03	2007		AGR	−4.4*	−4.0*	−5.04	1998
	RES	−2.70	−2.08	−2.98	2006		RES	−2.67	−2.43	−5.01	2006

Note: * shows that the null hypothesis of unit root can be rejected at 5% level of significance. The last columns indicate the structural break year in Zivot-Andrews unit root test.

When shocks are transitory, as we found for 12 cases, electricity consumption returns to its original equilibrium level regardless of government policies or other factors. In the majority of cases where electricity consumption is non-stationary and integrated in econometric models (to estimate the effects on real output), a co-integration test must be used because the coefficient estimate of electricity consumption is otherwise not statistically and economically meaningful. Finally, we can forecast electricity consumption easily only for our 12 stationary cases; for many non-stationary cases, forecasting is thwarted by stochastic behaviors.

The reported results are robust and reliable since we employ multiple unit root tests even though they may suffer from small sample bias. Future studies can potentially obtain more robust and less biased results once a longer time series of data becomes available. Nevertheless, this empirical work made use of all currently available data on electricity consumption for the 12 regions of Turkey, and fulfills a significant gap in the literature by analyzing the stationarity of electricity consumption by sectors at the regional level.

5. Conclusions

Several limitations arise in the literature that focuses on the stationarity properties of factors affecting energy consumption. First, the studies in this area tend to employ panel data and thus single-country studies of this kind are limited in number. Second, many of the single-country studies focus on the United States (U.S.). Third, the majority of existing studies only consider aggregate energy consumption. Last, few studies employ sub-national data, which tends to be scarce. To address the gap in the literature, we investigated the stationarity of electricity consumption for five sectors across 12 regions of Turkey. Hence, we analyze a total of 60 cases to offer useful information to Turkish policy makers. To end this, we apply the Dickey-Fuller unit root test based on Generalized Least Squares regression (DFGLS), the Phillips-Perron unit root test (PP), and the Zivot-Andrews unit root test with one endogenous structural break (ZA).

Regarding our empirical findings, the DFGLS and the PP suggest that electricity consumption is stationary in 7 cases or 12 cases when we take into account structural change by using the ZA unit root test. Because structural change appears in the analyzed data, we place more trust in the results reported by the ZA test with one endogenously determined break. In short, we conclude that shocks to electricity consumption have transitory effects in only 12 of our 60 cases. In these cases, past consumption can also be used to forecast future consumption due to stationarity. However, the potential for innovation may be limited because consumption tends to return to its equilibrium level.

Regarding implications, we would expect that government policies to encourage or discourage the use of electricity to have a permanent impact on electricity consumption in the vast majority of cases in Turkey given they are non-stationary. We leave for further studies the investigation of possible reasons behind the differences among sectors and regions in terms of stationarity and thus the potential for innovation that might affect electricity consumption. Moreover, further studies may investigate the fractional integration properties of electricity consumption as well as the linearity of consumption by sectors at the regional level once a longer time series of data becomes available. For now, these issues are beyond the scope of this study.

Appendix. Descriptive Statistics Table.

<table>
<tr><th>TR1</th><th>TR2</th></tr>
<tr><th>Variable|Obs Mean Std. Dev. Min Max</th><th>Variable|Obs Mean Std. Dev. Min Max</th></tr>
<tr><td>tot|19 16.91 0.30 16.39 17.33</td><td>tot|19 16.91 0.30 16.39 17.33</td></tr>
<tr><td>ind|19 15.83 0.13 15.49 16.07</td><td>ind|19 15.83 0.13 15.49 16.07</td></tr>
<tr><td>bus|19 15.40 0.69 14.15 16.29</td><td>bus|19 15.40 0.69 14.15 16.29</td></tr>
<tr><td>agr|19 7.89 1.30 6.16 12.47</td><td>agr|19 7.89 1.30 6.16 12.47</td></tr>
<tr><td>res|19 15.75 0.36 15.02 16.18</td><td>res|19 15.75 0.36 15.02 16.18</td></tr>
<tr><td>TR3</td><td>TR4</td></tr>
<tr><td>tot|19 16.81 0.32 16.31 17.27</td><td>tot|19 16.75 0.35 16.04 17.25</td></tr>
<tr><td>ind|19 16.17 0.26 15.80 16.57</td><td>ind|19 16.42 0.34 15.71 16.87</td></tr>
<tr><td>bus|19 14.54 0.58 13.53 15.44</td><td>bus|19 14.08 0.68 12.85 15.17</td></tr>
<tr><td>agr|19 13.14 0.46 12.28 13.68</td><td>agr|19 11.46 0.52 10.42 12.21</td></tr>
<tr><td>res|19 15.25 0.41 14.49 15.79</td><td>res|19 14.78 0 0.36 14.05 15.29</td></tr>
<tr><td>TR5</td><td>TR6</td></tr>
<tr><td>tot|19 16.11 0.36 15.56 16.63</td><td>tot|19 16.59 0.36 15.98 17.16</td></tr>
<tr><td>ind|19 15.05 0.32 14.36 15.49</td><td>ind|19 15.90 0.31 15.41 16.48</td></tr>
<tr><td>bus|19 14.24 0.56 13.32 15.06</td><td>bus|19 14.56 0.59 13.41 15.47</td></tr>
<tr><td>agr|19 13.05 0.58 11.91 13.87</td><td>agr|19 12.95 0.37 12.20 13.40</td></tr>
<tr><td>res|19 14.84 0 0.35 14.20 15.33</td><td>res|19 15.05 0 0.41 14.31 15.66</td></tr>
<tr><td>TR7</td><td>TR8</td></tr>
<tr><td>tot|19 15.40 0.32 14.87 15.89</td><td>tot|19 15.67 0.28 15.16 16.13</td></tr>
<tr><td>ind|19 14.62 0.29 14.20 15.01</td><td>ind|19 15.08 0.24 14.58 15.50</td></tr>
<tr><td>bus|19 12.79 0.71 11.66 14.00</td><td>bus|19 12.99 0.64 11.87 14.01</td></tr>
<tr><td>agr|19 13.00 0.35 12.14 13.39</td><td>agr|19 10.89 0.46 9.97 11.63</td></tr>
<tr><td>res|19 13.93 0 0.34 13.23 14.42</td><td>res|19 14.27 0.31 13.72 14.70</td></tr>
<tr><td>TR9</td><td>TR10</td></tr>
<tr><td>tot|19 14.68 0.33 14.18 15.21</td><td>tot|19 14.10 0.37 13.39 14.61</td></tr>
<tr><td>ind|19 13.49 0.20 13.19 13.86</td><td>ind|19 12.41 0.31 11.90 13.07</td></tr>
<tr><td>bus|19 12.46 0.72 11.30 13.55</td><td>bus|19 11.77 0.70 10.41 12.80</td></tr>
<tr><td>agr|19 6.92 0.48 5.92 7.99</td><td>agr|19 9.82 0.33 9.26 10.34</td></tr>
<tr><td>res|19 13.73 0 0.37 13.10 14.26</td><td>res|19 13.14 0.40 12.35 13.66</td></tr>
<tr><td>TR11</td><td>TR12</td></tr>
<tr><td>tot|19 14.77 0.33 14.23 15.32</td><td>tot|19 15.77 0.40 15.00 16.31</td></tr>
<tr><td>ind|19 13.66 0.30 13.22 14.33</td><td>ind|19 14.88 0.39 14.11 15.44</td></tr>
<tr><td>bus|19 12.17 0.75 10.85 13.27</td><td>bus|19 13.00 0.87 11.46 14.37</td></tr>
<tr><td>agr|19 11.20 0.63 9.97 11.91</td><td>agr|19 13.30 0.34 12.69 13.90</td></tr>
<tr><td>res|19 13.50 0.40 12.81 14.05</td><td>res|19 14.22 0.45 13.37 14.79</td></tr>
</table>

References

Agnolucci, P., Venn, A., 2011. Industrial energy intensities in the UK: is there a deterministic or stochastic difference among sectors? Appl. Econ. 43, 1447–1462.

Altinay, G., Karagol, E., 2004. Structural break, unit root, and the causality between energy consumption and GDP in Turkey. Energy Econ. 26 (6), 985–994.

Apergis, N., Payne, J.E., 2010. Structural breaks and petroleum consumption in US states: are shocks transitory or permanent? Energy Policy 38, 6375–6378.

Apergis, N., Loomis, D., Payne, J.E., 2010a. Are fluctuations in coal consumption transitory or permanent? Evidence from a panel of US states. Appl. Energy 87, 2424–2426.

Apergis, N., Loomis, D., Payne, J.E., 2010b. Are shocks to natural gas consumption temporary or permanent? Evidence from a panel of US states. Energy Policy 38, 4734–4736.

Apergis, N., Tsoumas, C., 2011. Integration properties of disaggregated solar, geothermal and biomass energy consumption in the US. Energy Policy 39, 5474–5479.

Aslan, A., 2011. Does natural gas consumption follow a nonlinear path over time? Evidence from 50 states. Renew. Sustain Energy Rev. 15, 4466–4469.

Barros, C.P., Gil-Alana, L.A., Payne, J.E., 2013. Evidence of long memory behavior in U.S. Nuclear electricity net generation. Energy Syst. 4 (1), 99–107.

Chen, P.F., Lee, C.C., 2007. Is energy consumption per capita broken stationary? New evidence from regional-based panels. Energy Policy 35, 3526–3540.

Elliott, G., Rotherberg, T.J., Stock, J.H., 1996. Efficient tests for an autoregressive unit root. Econometrica 64, 813–836.

Gil-Alana, L.A., Loomis, D., Payne, J.E., 2010. Does energy consumption by the U.S. Electric power sector exhibit long memory behavior? Energy Policy 38 (11), 7512–7518.

Hasanov, M., Telatar, E., 2011. A re-examination of stationarity of energy consumption: evidence from new unit root tests. Energy Policy 39 (12), 7726–7738.

Karanfil, F., 2009. How many times again will we examine the energy-income nexus using a limited range of traditional econometric tools? Energy Policy 37, 1191–1194.

Lean, H.H., Smyth, R., 2009. Long memory in US disaggregated petroleum consumption: evidence from univariate and multivariate LM tests for fractional integration. Energy Policy 37, 3205–3211.

Lean, H.H., Smyth, R., 2013. Are fluctuations in US production of renewable energy

permanent or transitory? Appl. Energy 101 (1), 483–488.
Lean, H.H., Smyth, R., 2014. Are shocks to disaggregated energy consumption in Malaysia permanent or temporary? Evidence from LM unit root tests with structural breaks. Renew. Sustain Energy Rev. 31, 319–328.
Mishra, V., Sharma, S., Smyth, R., 2009. Are fluctuations in energy consumption per capita transitory? Evidence from a panel of Pacific Island countries. Energy Policy 37, 2318–2326.
Narayan, P.K., Smyth, R., 2007. Are shocks to energy consumption permanent or temporary? Evidence from 182 countries. Energy Policy 35, 333–341.
Narayan, P.K., Narayan, S., Smyth, R., 2008. Are oil shocks permanent or temporary? Panel data evidence from crude oil and NGL production in 60 countries. Energy Econ. 30, 919–936.
Narayan, P.K., Narayan, S., Popp, S., 2010. Energy consumption at the state level: the unit root null hypothesis from Australia. Appl. Energy 87, 1953–1962.
Ozturk, I., Aslan, A., 2011. Are fluctuations in energy consumption per capita transitory? Evidence from Turkey. Energy Explor Exploit. 29, 161–168.
Phillips, P.C.B., Perron, P., 1988. Testing for a unit root in time series regression. Biometrika 75, 335–346.
Shahbaz, M., Khraief, N., Mahalik, M.K., Zaman, K.U., 2014. Are fluctuations in natural gas consumption per capita transitory? Evidence from time series and panel unit root tests. Energy 78, 183–195.
Smyth, R., 2013. Are fluctuations in energy variables permanent or transitory? A survey of the literature on the integration properties of energy consumption and production. Appl. Energy 104, 371–378.
Smyth, R., Narayan, P.K., 2015. Applied econometrics and implications for energy economics research. Energy Econ. 50, 351–358.
Wooldridge, J., 2015 Oct 8. Introductory econometrics: A modern approach. Nelson Education.
Yilanci, V., Tunali, C.B., 2014. Are fluctuations in energy consumption transitory or permanent? Evidence from a Fourier LM unit root test. Renew. Sustain Energy Rev. 36, 20–25.
Zivot, E., Andrews, D.W.K., 2002. Further evidence on the great crash, the oil-price shock, and the unit-Root hypothesis. J. Bus. Econ. Stat. 20 (1), 25–44.