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Can the electricity market be characterised by asymmetric behaviour?

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ABSTRACT

In this paper, we test for asymmetric behaviour of industrial and residential electricity demand for the G7 countries, using the entropy-based test for symmetry suggested by [Racine, J., and Maasoumi, E., 2007. A versatile and robust metric entropy test of time-reversibility, and other hypotheses. Journal of Econometrics 138(2), 547–567; Racine, J., and Maasoumi, E., 2008. A robust entropy-based test of asymmetry for discrete and continuous processes. Econometric Reviews 28, 246–261], the Triples test of [Randles, R., Flinger, M., Policello, G., and Wolfe, D., 1980. An asymptotically distribution-free test for symmetry versus asymmetry. Journal of the American Statistical Association 75, 168–172] and the [Bai, J., and Ng, S., 2001. A consistent test for conditional symmetry in time series models. Journal of Econometrics 103, 225–258] test for conditional symmetry. Using data that spans over three decades, we find overwhelming evidence of conditional symmetry of residential and industrial electricity consumption. This finding implies that the use of econometric tests based on linear data generating processes is credible.

1. Introduction

The branch of research in energy economics that has become popular recently relates to testing the unit root null hypothesis. Some of the more recent contributions include (Narayan et al., 2008a, b) and (Narayan and Smyth, 2007). Narayan et al. (2008a, b) examine the unit root properties of crude oil production for 60 countries employing a range of panel data unit root tests for the period 1971–2003. They find mixed results on the unit root properties of crude oil production. Narayan and Smyth (2007) examine the unit root null hypothesis for per capita energy consumption for 182 countries using times series and panel data. They find strong evidence of stationarity of energy consumption when they use panel unit root tests.

There are some studies that have applied an ADF-type unit root test with one structural break to test whether energy consumption is stationary (Altinay and Karagol, 2004; Lee, 2006); and there are some studies which have applied panel data unit root tests to energy consumption (Joyeux and Ripple, 2007; Narayan and Smyth, 2008). Related studies include (Perman and Stein, 2003) and (Strazicich and List, 2003), who applied panel data unit root tests to examine the stationarity properties of carbon emissions. Finally, Tauchmann (2006) applied a panel unit root test to examine the stationarity properties of electricity generation.

A feature of all these studies is that in testing the unit root null hypothesis, or the null of stationarity, they assume that the data generating process is linear (or symmetric). If this is not the case; that is, if the data generating process is nonlinear (or asymmetric), then the validity of the findings from the above-mentioned studies are questionable.

On the literature that examines asymmetric behaviour of macroeconomic series, generally the findings are mixed. However, recent studies using more advanced techniques show that advanced industrialised economies display less evidence of asymmetry (see Narayan and Popp, 2008) while Asian countries display greater evidence of asymmetry (see Narayan and Narayan, 2008).

On the literature on symmetric properties of energy variables, there are only three studies that directly test for symmetry. Murry and Zhu (2008) examine symmetry properties of natural gas hubs for the US, Godby et al. (2000) examine symmetry properties of prices in the Canadian retail gasoline market, and Narayan and Narayan (2007) examine symmetry properties of the volatility of crude oil prices. In addition, while there are several studies of nonlinearities in energy variables, none of the studies have considered a direct test of symmetry of electricity variables.

Given the existing research gap in this area, the goal of this paper is to examine whether or not electricity demand is symmetric. To achieve this goal, we concentrate on the G7 countries and consider both residential and industrial electricity

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demand. Our econometric approach is varied in the sense that we use three different methods: the new entropy-based test for conditional symmetry proposed by Racine and Maasoumi (2007, 2008), the Triples test developed by Randles et al. (1980), and the conditional symmetry test suggested by Bai and Ng (2001). We found strong evidence that both residential and industrial electricity demand have symmetric distributions.

We organise the balance of the paper as follows. In Section 2, we discuss the main motivations for understanding whether or not electricity consumption follows a symmetric distribution. In Section 3, we discuss our econometric approaches. In Section 4, we discuss the data and results. In the final section, we provide some concluding remarks.

2. Why do asymmetries matter for electricity demand?

There are a number of reasons why asymmetries in electricity consumption/demand matter. These reasons are related to both theory and policy. First, if electricity consumption is found to be asymmetric then this implies that the positive and negative shocks on electricity consumption are not symmetric. In the broader literature on energy, in particularly oil prices, it has been shown that shocks have asymmetric effects on oil prices (see Narayan and Narayan, 2007). Sources of asymmetries have been widely discussed in the macroeconomics literature and are relevant for the energy markets, since the impact seems to flow through prices. For example, it has been argued and shown, among others, by Tobin (1972) that prices are asymmetric—they are more flexible when going up than when going down. Ball and Mankiw (1994) argue that since prices are sticky downwards, a fall in aggregate demand reduces output substantially, while a rise in demand has a small absolute effect on output because prices adjust more rapidly. It follows, given the positive correlation between output and electricity consumption documented in the energy economics literature, that any fall in output will lead to a fall in electricity demand and vice versa. This suggests that shocks have asymmetric effects on electricity demand; for a recent analysis of the impact of shocks on electricity demand, see Narayan et al. (2008a, b).

Second, as Kiani and Bidarkota (2004) argue, nonlinearities would invalidate measures of persistence of monetary policies and other shocks on output that are based on linear models. If this is true the given positive correlation between electricity consumption and output, nonlinearities will also invalidate measures of persistence in electricity demand models, since the extant literature that estimates the determinants of electricity demand assume that the model is linear. It follows that electricity demand asymmetries tend to question theoretical models estimated and tested on the assumption of a linear data generating process.

Furthermore, McQueen and Thorley, (1993) argue that for policy and budgetary reasons predicting economic time series, such as unemployment, is critical because if the series is asymmetric then linear forecasting models will give inaccurate results. One branch of research (see, inter alia, Bowden and Payne, 2008; Barthelmie et al., 2008) in energy economics has focussed on forecasting electricity demand. These studies assume that they have a forecasting model which is linear. Presence of asymmetries in electricity demand will thus invalidate such forecasting models.

3. Methodology

The aim of this section is to briefly discuss the three tests for symmetry that we use in this paper. These tests are the entropy-based test of Racine and Maasoumi (2007, 2008), the Triples test developed by Randles et al. (1980), and the conditional symmetry test suggested by Bai and Ng (2001).

3.1. An entropy-based test for asymmetry

Entropy-based measures of divergence have become famous for multiple reasons. Granger et al. (2004) have used it for measuring nonlinear dependence, Racine and Maasoumi (2007) have used it to evaluate the goodness-of-fit in nonlinear models and time-reversibility, and Racine and Maasoumi (2008) have used it to test for asymmetric behaviour of macroeconomic variables, including stock market returns (see also Maasoumi and Racine, 2002).

Let us begin with a stationary series $\{Y_t\}_{t=1}^{T}$, and let $\mu_y = E[Y_t]$, let $f(y)$ denote the density function of the random variable Y_t. Now let $\tilde{Y}_t = -Y_t + 2\mu_y$ denote a rotation of Y_t about its means, and let $f(\tilde{y})$ denote the density function of the random variable $\tilde{Y}_t$.

The series Y_t is symmetric about the mean if $f(y) \equiv f(\tilde{y})$. It follows that a test for asymmetry about the mean takes the following form:

$$H_0 : f(y) = f(\tilde{y}) \quad \text{for all } y.$$

Following Racine and Maasoumi (2007, 2008), we consider the Bhattacharya–Matusita–Hellinger measure of dependence:

$$S_\rho = \frac{1}{2}\int_{-\infty}^{\infty}\left(f_1^{1/2} - f_2^{1/2}\right) dy,$$

where $f_1 = f(y)$ is the marginal density of the random variable Y and $f_2 = f(\tilde{y})$ has the same feature for $\tilde{Y}$. To test for the null of symmetry, Racine and Maasoumi (2007, 2008) recommend the kernel estimator proposed by Parzen (1962), and the null distribution of the kernel-based implementation of S_ρ is obtained through a bootstrap re-sampling approach; for details, see (Racine and Maasoumi, 2007) and (Granger et al., 2004). The null hypothesis of symmetry is true when $S_\rho = 0$. The *R* code written and provided by Racine is used to compute the test statistic. The code is implemented using the *R* software available online at http://www.r-project.org.

3.2. Triples test

The Triples test proposed by Randles et al. (1980) is conducted as follows. From a sample of size N, $(x_1, \ldots, x_N)$, all possible $\binom{N}{3}$ triples (x_i, x_j, x_k), $1 \le i < j < k \le N$ are considered. These three observations form a right triple if the central value is closer to the lower observation. It is called a left triple if the the middle observation is closer to the higher observation. The Triples test statistic U is based on the difference between the number of right triples and the number of left triples, and is as follows:

$$U = \frac{\sqrt{[]}N\hat{\eta}}{\hat{\sigma}_{\hat{\eta}}}, \tag{1}$$

where

$$\hat{\eta} = \binom{N}{3}^{-1} \sum_{i<j<k} f(x_i, x_j, x_k), \tag{2}$$

with

$$f(x_i, x_j, x_k) = \frac{1}{3}[\text{sign}(x_i + x_j - 2x_k) + \text{sign}(x_i + x_k - 2x_j) + \text{sign}(x_j + x_k - 2x_i)], \tag{3}$$

where sign (a) is equal to -1, 0, and 1 for a being lower, equal or greater than zero, respectively. So, $f(\cdot)$ can take the values

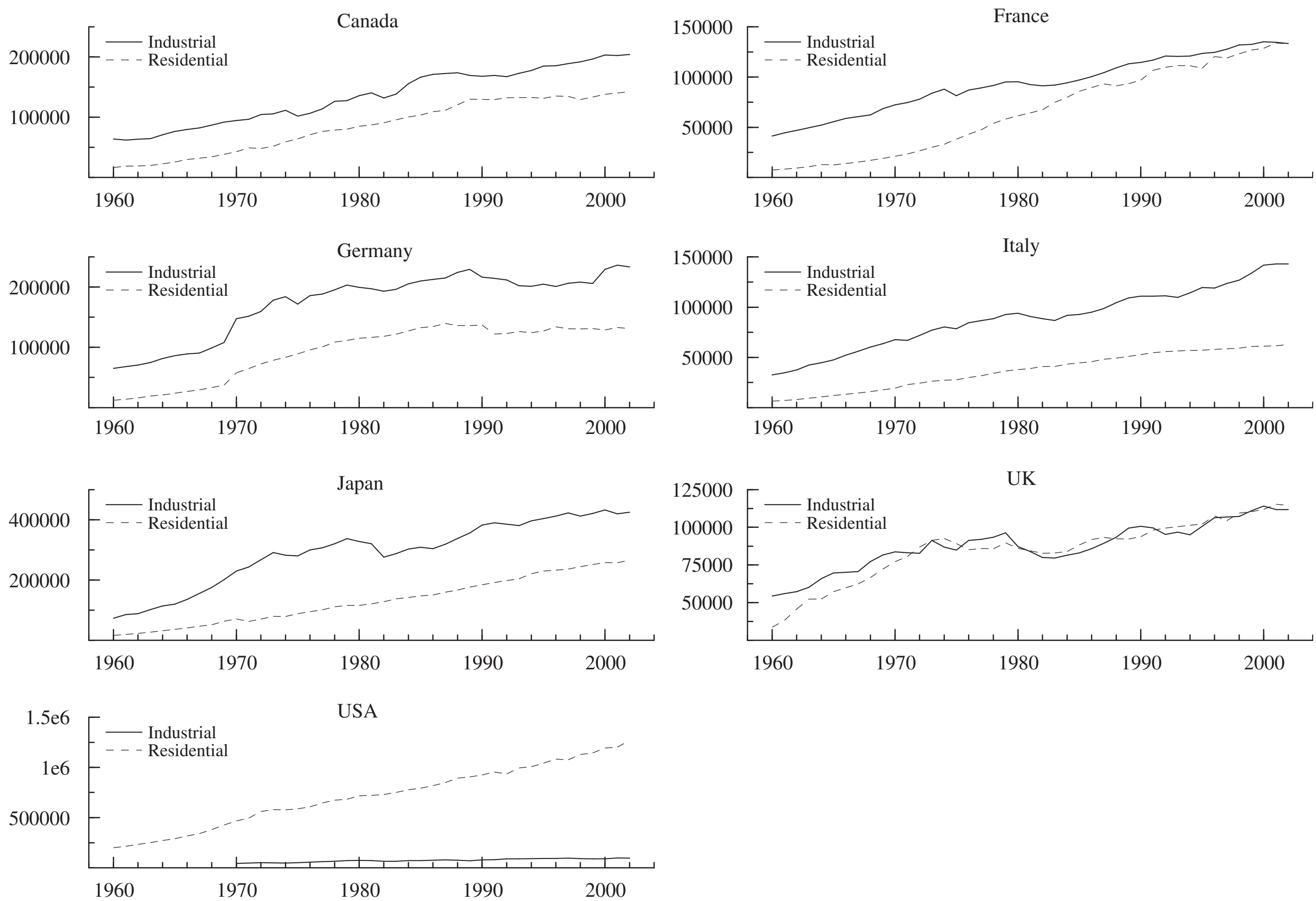

Fig. 1. Time series polygon of industrial and residential electricity demand in the G7 countries.

$-\frac{1}{3}$, 0 and $\frac{1}{3}$. The standard deviation $\hat{\sigma}_{\hat{\eta}}$ is defined as

$$\hat{\sigma}_{\hat{\eta}} = \sqrt{[\,]}\binom{N}{3}^{-1}\sum_{c=1}^{3}\binom{3}{c}\binom{N-3}{3-c}\hat{\varsigma}_c, \tag{4}$$

with

$$\hat{\varsigma}_1 = N^{-1}\sum_{i=1}^{N}[f_1(x_i) - \hat{\eta}]^2, \tag{5}$$

$$f_1(x_1) = \binom{N-1}{2}^{-1}\sum_{j<k,i\neq j,i\neq k}\sum f(x_i, x_j, x_k), \tag{6}$$

$$\hat{\varsigma}_2 = \binom{N}{2}^{-1}\sum_{j<k}\sum[f_2(x_j, x_k) - \hat{\eta}]^2, \tag{7}$$

$$f_2(x_j, x_k) = (N-2)^{-1}\sum_{i=1,i\neq j\neq k,i\neq k}\sum f(x_i, x_j, x_k), \tag{8}$$

and

$$\hat{\varsigma}_3 = \frac{1}{9} - \hat{\eta}^2. \tag{9}$$

The null hypothesis of $U = 0$ that the distribution is symmetric about the median is rejected when there are significantly more right triples than left triples (indicating right skewness or positive asymmetry) or more left triples than right triples (indicating left skewness or negative asymmetry). The test statistic U is distributed $N(0,1)$. The favourable properties of the Triples test are discussed in Verbrugge (1997) and Razzak (2001), and we refer interested readers to these sources.

3.3. Bai–Ng test for conditional symmetry

Bai and Ng (2001) have developed a test for conditional symmetry for time series data. The test is based on the following model:

$$Y_t = h(\Omega_t, \beta) + \sigma^2(\Omega_t, \lambda)e_t,$$

where $h(\Omega_t,\beta)$ is the conditional mean, $\sigma^2(\Omega_t,\lambda)$ the conditional variance of Y_t, Ω_t the information set at time t consisting of an infinite number of lagged variables of Y_t and X_t, and e_t the zero mean disturbance with unit variance and independent of the elements of Ω_t. Conditional symmetry of Y_t with respect to its conditional mean is equivalent to the symmetry of e_t about zero, i.e. $f(e) = f(-e)$ for all e where f is the density function of e. So, the principle idea of the test by Bai and Ng (2001) is to compare the empirical distribution of e_t and that of $-e_t$, where $t = 1, \ldots, T$. To do so, Bai and Ng use the CS statistic which converges to a function of standard Brownian motion on [0,1].[1] The asymptotic critical values of the CS statistic are 2.78, 2.21, and 1.91 at the 1%, 5% and 10% significance levels, respectively.

[1] For more details on the derivation of the test statistic, see (Bai and Ng, 2001) or (Belaire-Franch and Peiro, 2003).

4. Data and results

4.1. Data

The empirical analysis is based on the seven most industrialised countries, namely the USA, the UK, Japan, Italy, Germany, Canada, and France (the G7 countries). We use annual time series data for the period 1960–2002 on residential and industrial electricity consumption, except for the industrial electricity consumption of the USA, for which we just have data for the period 1970–2002. Electricity consumption is measured in kWh, and all data are obtained from the *International Energy Agency database* published by the OECD. All data were converted into natural logarithmic form prior to conducting the empirical analysis.

The time series plot of the raw data is provided in Fig. 1. We make two observations from the plots of residential and industrial electricity consumption. First, there is a positive trend in both series. Second, most of the series seem to have been impacted by structural breaks. This conjecture is supported by the histogram and the estimated density of the industrial and residential electricity demand which are provided in Figs. 2 and 3, respectively. The occurance of structural breaks in a series can lead to a bimodal distribution (a distribution with two modes) which is evident for most of the series. The structural breaks seem to occur towards the late 1970s and in the mid-1980s in most of the cases. We will more formally explore the timing of the structural breaks later in this section.

Some descriptive statistics of the data are presented in Table 1. In addition to the mean and standard deviation of industrial and residential electricity demand, we also report the coefficient of variation, skewness, and kurtosis in columns 5, 6, and 7, respectively. The coefficient of variation is defined as the ratio of the standard deviation and the mean. It is used to compare the dispersion when the mean of the series differs much. The absolute dispersion measured by the standard deviation is expected to be higher for those series with a higher mean value. It seems that the residential electricity demand varies much more relative to the industrial electricity demand.

A skewness parameter lower than zero means that the distribution is left-skewed. We notice that for industrial electricity demand, the skewness parameter is lower than zero for all the G7 countries, while for residential electricity demand, except for France and Japan, the skewness parameter is lower than zero. This implies that the distribution is left-skewed in most cases.

A kurtosis parameter lower than 3 means that the distribution is less peaked than the normal distribution. A pre-requisite for the skewness and kurtosis to be a sensible measure is to have a unimodal distribution. We notice that the kurtosis is lower than 3 for all the G7 countries with respect to industrial electricity demand while in case of residential electricity demand it is slight higher than 3 only in case of the UK.

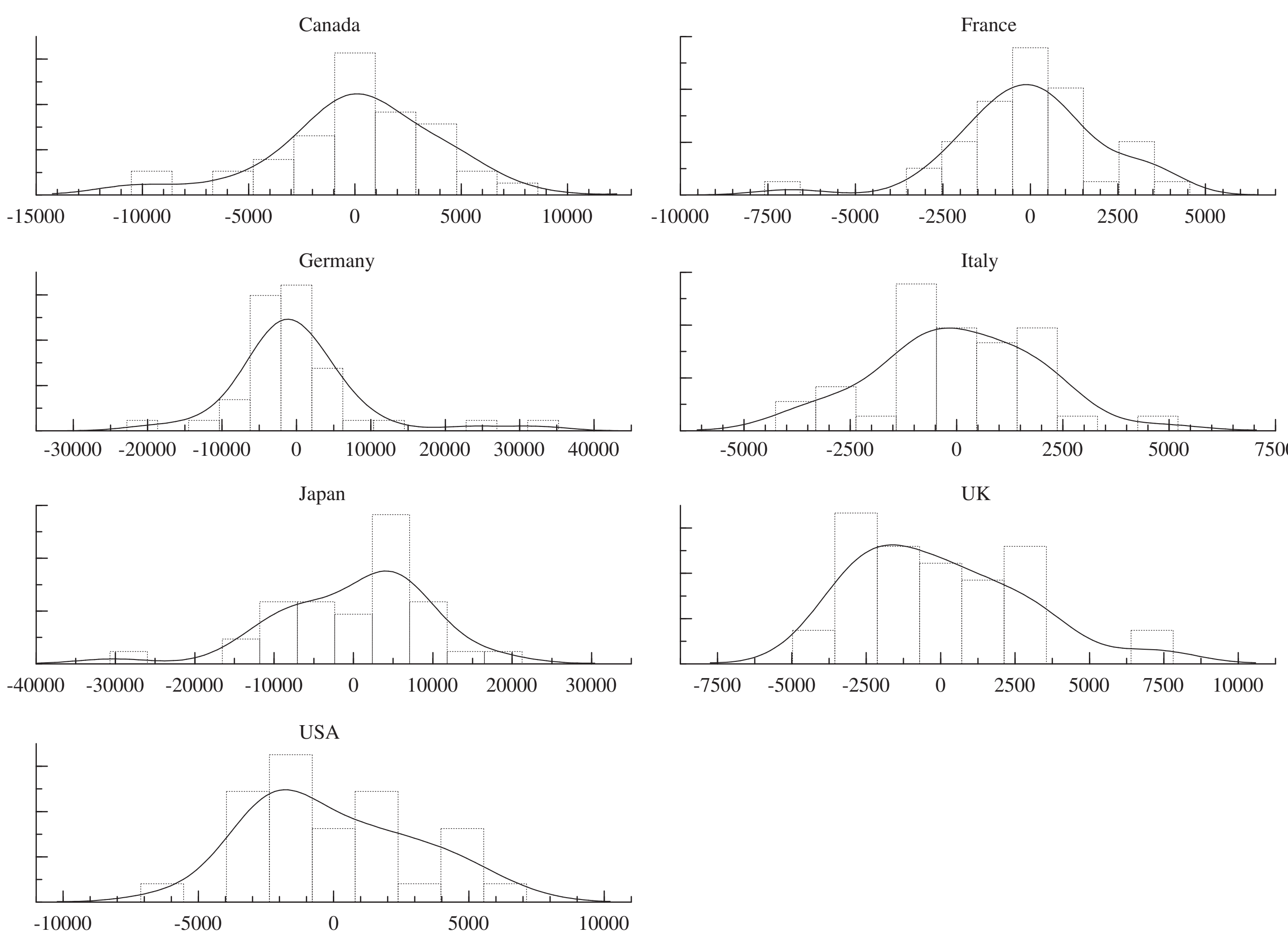

Fig. 2. Histogram and estimated density of industrial electricity demand of the G7 countries.

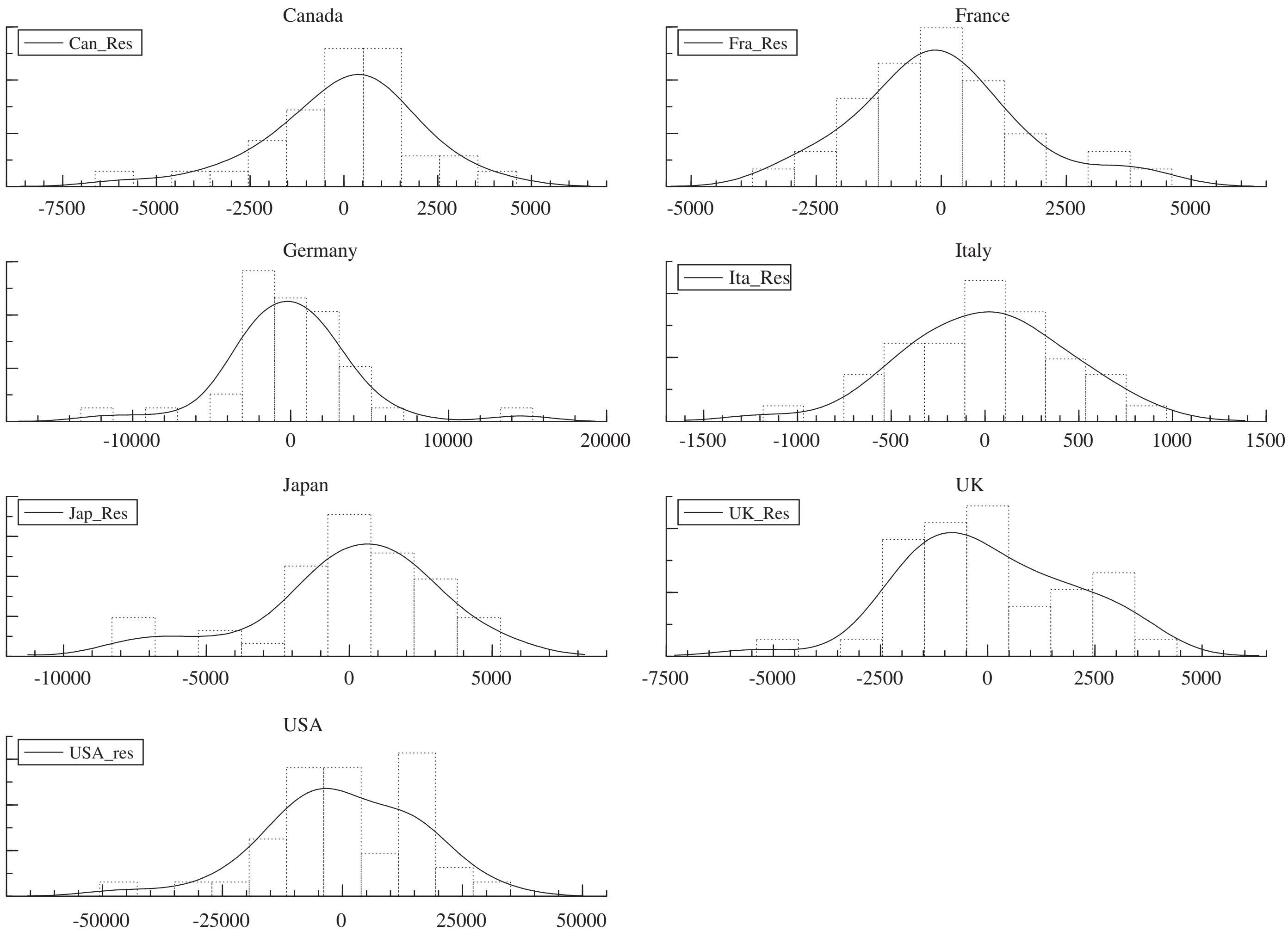

Fig. 3. Histogram and estimated density of residential electricity demand of the G7 countries.

Table 1
Some descriptive statistics of the industrial and residential electricity demand of the G7 countries.

Countries	Industrial					
	T	Mean	Std	Coeff. of Variation	Skewness	Kurtosis
Canada	43	134894	45889	0.34	−0.10	1.64
France	43	93256	27918	0.30	−0.19	1.97
Germany	43	173367	53958	0.31	−0.94	2.37
Italy	43	89006	30351	0.34	−0.10	2.24
Japan	43	291472	107835	0.37	−0.62	2.29
UK	43	87652	15511	0.18	−0.36	2.60
USA	33	74361	16550	0.22	−0.27	1.90
	Residential					
Canada	43	85009	43449	0.51	−0.20	1.55
France	43	65902	43042	0.65	0.07	1.53
Germany	43	94288	44372	0.47	−0.76	1.97
Italy	43	37024	18434	0.50	−0.21	1.67
Japan	43	131385	77756	0.59	0.21	1.80
UK	43	84928	20284	0.24	−0.80	3.07
USA	43	714349	307075	0.43	−0.06	1.95

4.2. *Unit root test results*

The knowledge regarding the integrational properties of the data series is an important pre-requisite for the correct application of the symmetry tests discussed above. Hence, in this section, apart from applying the conventional Dickey–Fuller (DF) test that examines the null hypothesis of a unit root without taking into account a structural break, we also apply the Lee and Strazicich (2004) one endogenous structural break test and the (Lee and Strazicich, 2003) two endogenous break test. The LS tests are based on two different types of models: model A, which only allows for a break in the intercept, and model C, which allows for a break in both the intercept and the slope. Both these tests are based on the Lagrange multiplier (LM) principle and have been widely used in the energy economics literature (see, for instance, Narayan et al., 2008a, b).

The results from the unit root tests are reported in Table 2; in panel A for the G7 industrial electricity demand and in panel B for the G7 residential electricity demand. Beginning with the augmented DF test results for the industrial electricity demand, we find that we are unable to reject the unit root null hypothesis at conventional levels of significance for any of the G7 countries. As it is well-known, following the work of Perron (1989), that the failure to reject the unit root null may be a result of the presence of structural break(s), which the ADF test does not take into account. As a result, when we apply the LS one break test (Model A), we are able to reject the unit root null hypothesis for France and the USA at the 5% level. Results from Model C are slightly different in the sense that the null is not rejected in case of the USA and in addition to the rejection of the null hypothesis for France at the 5% level, it is also rejected, although weakly (at the 10% level), for Canada and Italy.

When we allow for two structural breaks, both Models A and C produce greater rejections of the null hypothesis. For instance, in case of Model A the unit root null is rejected at the 1% level for France and at the 10% level for Canada and the USA. On the other hand, results from Model C reveal that the null hypothesis can be rejected at the 1% level for Canada, Italy, Japan, and the UK, at the 5% level for France, and at the 10% level for the USA. Taken together, the results from Models A and C reveal that the unit root

Table 2
Unit root test results of the industrial electricity demand of the G7 countries.

Countries	Industrial															
	ADF		*LM one break model A*			*LM one break model C*			*LM two break model A*				*LM two break model C*			
	τ	*k*	τ	TB	*k*	τ	TB	*k*	τ	TB1	TB2	*k*	τ	TB1	TB2	*k*
Canada	−2.346	0	−3.301	1977	1	−4.365*	1981	4	−3.550*	1976	1983	2	−5.862***	1981	1990	4
France	−1.890	0	−3.609**	1977	1	−4.586**	1974	3	−4.656***	1973	1977	8	−5.294**	1978	1995	8
Germany	−1.265	0	−2.597	1977	3	−3.810	1977	3	−3.162	1982	1987	8	−4.894	1975	1988	8
Italy	−1.845	0	−2.026	1984	1	−4.354*	1980	3	−2.142	1975	1984	1	−5.897***	1979	1993	6
Japan	−1.421	0	−2.369	1982	3	−3.204	1970	1	−3.238	1981	1991	6	−6.939***	1980	1995	7
UK	−2.137	0	−2.227	1991	3	−4.129	1980	3	−2.684	1972	1979	1	−7.788***	1978	1993	8
USA	−2.566	0	−3.731**	1987	4	−4.059	1976	1	−3.698*	1984	1998	2	−5.160*	1980	1992	2
	Residential															
Canada	−0.437	0	−2.399	1971	3	−3.117	1983	3	−2.908	1973	1987	7	−7.436***	1973	1986	8
France	−2.597	0	−1.806	1995	2	−3.062	1976	0	−4.012**	1993	1995	8	−6.361***	1971	1983	2
Germany	−0.022	0	−2.096	1972	3	−3.556	1980	3	−3.205	1987	1990	8	−4.902	1973	1989	3
Italy	0.225	0	−2.159	1973	3	−3.114	1974	3	−3.372	1972	1990	6	−4.720	1970	1991	3
Japan	−2.300	0	−1.890	1994	0	−3.960	1987	0	−2.404	1970	1973	5	−5.381**	1979	1992	5
UK	−2.412	2	−1.578	1976	2	−3.311	1977	1	−2.374	1970	1984	7	−6.512***	1970	1981	5
USA	−2.100	0	−2.549	1980	0	−2.994	1979	2	−2.667	1978	1980	0	−4.797	1971	1990	3

*/**/***denotes rejection of the null hypothesis at the 10%/5%/1% significance level, respectively.

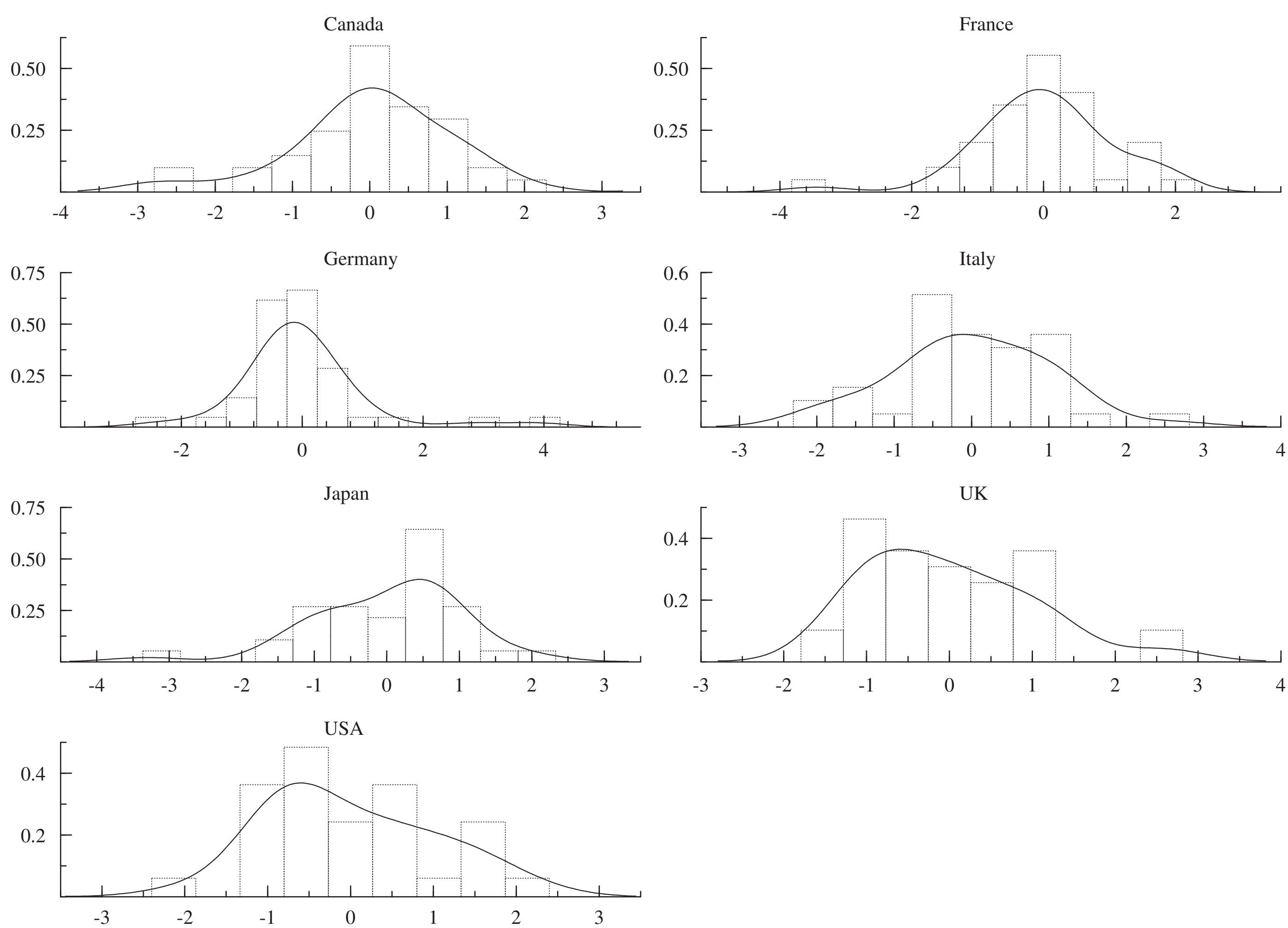

Fig. 4. Histogram and estimated density of standardized residuals of industrial electricity demand of the G7 countries.

null hypothesis can be rejected at the 10% level or better for all countries industrial electricity demand except for Germany. In terms of the timing of the structural breaks, most of the breaks tend to be associated with the oil price shocks of the 1970s and the early 1980s recessions.

We now turn to the results from the residential electricity demand. The augmented DF test results reveal that the unit root null hypothesis cannot be rejected for any of the G7 countries. The results from Models A and C of the LS one break test are also unable to reject the unit root null hypothesis at conventional levels of significance. However, when we apply the two break test, Model A rejects the unit root null in case of France at the 5% level, while Model C rejects the null at the 1% level for Canada, France, and the UK, and at the 5% level for Japan.

4.3. Symmetry test results

We used the results from Model C of the two break LM unit root test to construct the (standardized) residuals, which we analyse for conditional symmetry by means of the Maasoumi–Racine test. Depending on the outcome of the LM test, we detrended the series by including a trend or by differencing, always taking account of the two structural breaks in level and trend. The distributions of the detrended and standardized residuals, which are shown in Figs. 4 and 5, seem to be symmetric and unimodal. The symmetry hypothesis will be tested formally by means of the three tests discussed in the previous section.

We begin with the (Racine and Maasoumi, 2007) test for conditional asymmetries. To test for unconditional asymmetries is not recommended in the presence of structural breaks, because it could lead to spurious rejections of the null hypothesis of symmetry.

The results examining the null hypothesis of symmetry are reported in Table 3. The results are organised as follows. Column 2 reports the results for industrial electricity demand while column 3 reports results for residential electricity demand.

Our results are as follows. We are unable to reject the null hypothesis of symmetry for industrial electricity demand at conventional levels of significance. In case of residential electricity demand, however, we are able to reject the null of symmetry for Japan but only weakly—at the 8% level. Taken together, at the 5% level, we find that both industrial and residential electricity demand are symmetric.

We now consider results from the Triples test (results reported in column 4 of Table 3) and the Bai and Ng test (results reported in the final column). The null hypothesis that the distribution is symmetric is only rejected for the UK's industrial electricity demand at the 5% level. For the rest of the countries industrial

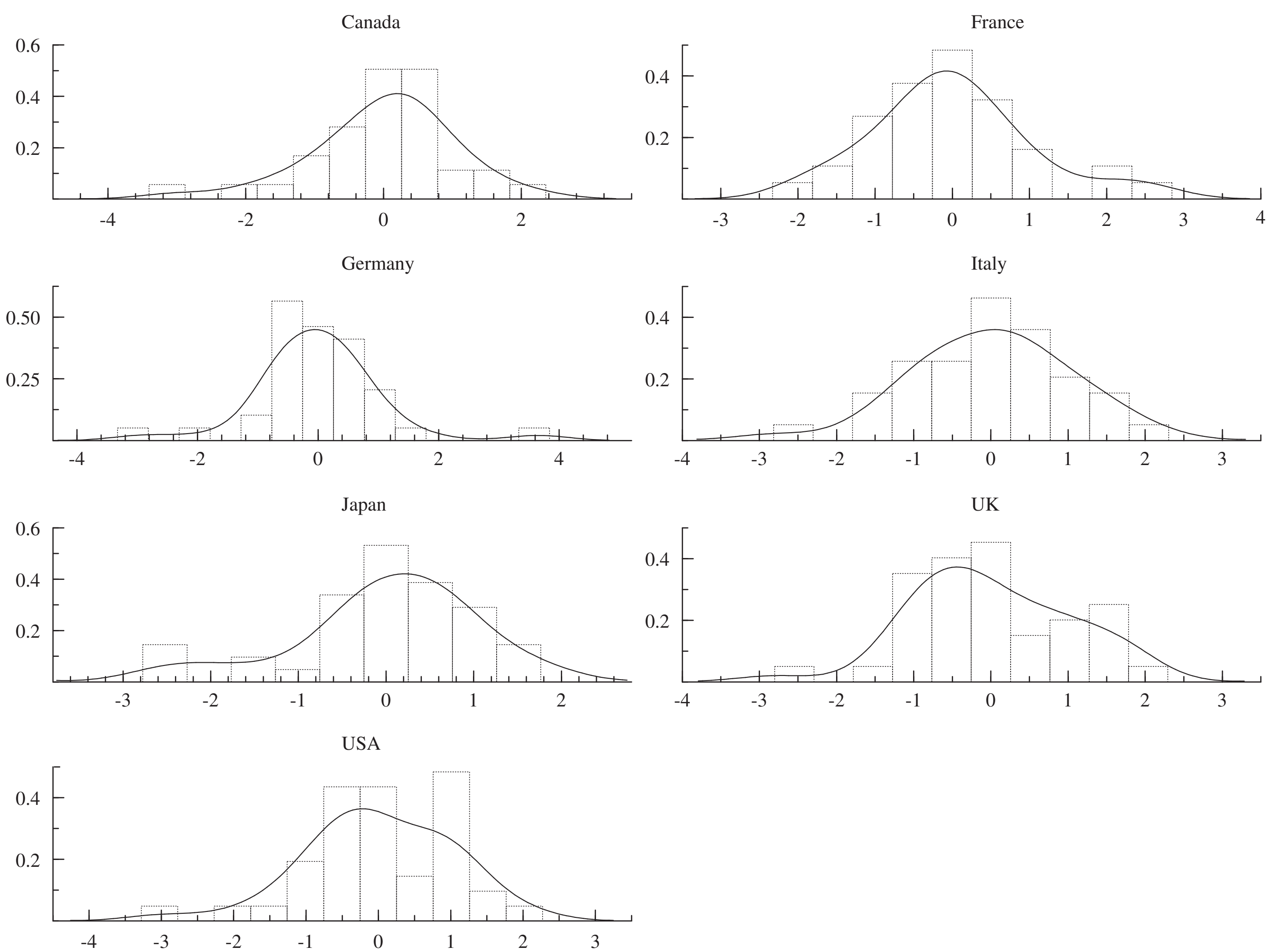

Fig. 5. Histogram and estimated density of standardized residuals of residential electricity demand of the G7 countries.

Table 3
Conditional symmetry test results for industrial and residential electricity demand of G7 countries.

	Country	Racine–Massoumi test statistic	Triples test	Bai–Ng test
Industrial	Canada	0.031	−0.773	0.726
	France	0.010	0.336	1.322
	Germany	0.028	0.836	5.456***
	Italy	0.001	−0.218	0.887
	Japan	0.011	−1.392	1.736
	UK	0.073	2.078**	1.209
	USA	0.016	1.540	1.407
Residential	Canada	0.009	−1.024	1.017
	France	0.021	0.748	1.087
	Germany	0.004	0.214	0.695
	Italy	0.003	−0.112	0.563
	Japan	0.098*	−1.605	1.837
	UK	0.009	1.001	1.854
	USA	0.007	−0.213	1.329

Note: the triples test statistic is asymptotically $N(0,1)$. The asymptotic critical values of the test by Bai and Ng (2001) are 2.78, 2.20 and 1.91 at the 1%, 5%, and 10% levels, respectively. */**/***denotes rejection of the null hypothesis of conditional symmetry at the 10%/5%/1% significance level, respectively.

electricity demand, evidence suggests that the distribution is symmetric. The null hypothesis of a symmetric distribution, on the other hand, cannot be rejected at the 10% level for any of the countries residential electricity demand.

Results from the Bai and Ng test suggest that the null hypothesis of conditional symmetry is only rejected for Germany's industrial electricity demand at the 1% level. For the rest of the countries, industrial electricity demand follows a symmetric distribution. For residential electricity demand, there is no evidence of asymmetry.

The asymmetric nature of Germany's industrial electricity demand may be as a result of several events that took place on the German electricity market, which may have contributed to the nonlinear structure of industrial electricity demand. For example, before electricity market liberalisation in 1999 there were eight major electricity companies. This number had reduced to four by 2001, as mergers and acquisitions took place. The capacity share of these four companies within a matter of a few years increased to 90% of the market (Weron, 2006).

The second major activity on the German electricity market relates to the implementation of a negotiated third party access to the electricity network, which was inefficient and collapsed, leading to bankruptcy of several retailers in 2004 (Weron, 2006).

We conclude the results with the following note. All the results provide robust support for the hypothesis of conditional symmetry. It should, however, be noted that a non-rejection of the null hypothesis is not an evidence of the correctness of the null hypothesis. On the contrary, it is well-known from the work of Psaradakis and Sola (2003), among others, that the symmetry tests suffer from the low power.

5. Concluding comments

The goal of the paper was to test for asymmetric behaviour of industrial and residential electricity demand for the G7 countries using the entropy-based test for symmetry suggested by Racine and Maasoumi (2007, 2008), the Triples test developed by Randles et al. (1980), and the conditional symmetry test suggested by Bai and Ng (2001). We find robust evidence that both industrial and residential electricity demand have a symmetric distribution.

The main implication of our finding is that the extant literature which models electricity demand without accounting for asymmetry – or nonlinear modelling approaches – is reliable in terms of their policy implications. One branch of this literature (see, among others, Altinay and Karagol, 2004; Narayan and Smyth, 2007; Narayan et al., 2008a, b) has attempted to test for unit roots in energy-type variables. The unit root tests used assume that the data generating process is linear. Our findings reveal that using such tests for statistical exercises in the energy economics literature is valid.

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