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Testing for convergence in electricity consumption across Croatian regions at the consumer's sectoral level

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ABSTRACT

Using the panel unit tests with and without structural break(s), the convergence hypothesis in relative per capita electricity consumption series is tested across Croatian regions during the period 2001–2013. The results are mixed, depending primarily on the consumption sector considered and the test applied. They indicate the necessity to conduct analysis and formulate energy policy measures on the sector-disaggregated and regional-specific electricity consumption time series.

The Croatian electricity markets are not fully integrated, and some regions are faced with statistically significant structural break(s), demonstrating thereby the Croatian gradual energy reform process with several sudden innovations, significant regional differences, and the market dependence on expectations, domestic and international economic and non-economic innovations. The impacts of innovations are likely to be permanent for most of the regions, and their electricity consumption behaviours are likely to be path dependent. Consequently, innovations into the energy markets, including government interventions, may have long-run effects, indicating that space and time for experimenting with alternative mechanisms are quite limited.

1. Introduction

The literature on the convergence hypothesis focuses mainly on income convergence. However, several studies have recently appeared in which convergence is empirically investigated in terms of per capita energy consumption (for a review, see Hsu et al., 2008; Aslan and Kum, 2011; Kum, 2012; Smyth, 2013; Shahbaz et al., 2013). Thereby, convergence emerges if the countries with low energy consumption are catching up with the countries with higher energy consumption (Robinson, 2007; Mohammadi and Ram, 2012; Meng et al., 2013; Mishra and Smyth, 2014). The use of per capita energy consumption in testing energy convergence is important since it indicates not only whether convergence occurs, but it also motivates to study the reasons for convergence or the potential sources of divergence. Since energy is an important but not free input in the production process, it is important to know whether it is used in an efficient and sustainable way. Moreover, because energy consumption is known to be by far the most pollutant gas emitting activity (Le Pen and Sevi, 2010), and climate change and shortage of energy the main challenges today, a deep understanding of the energy convergence process may offer useful policy suggestions for sustainable energy consumption and efforts to decrease carbon dioxide emissions.

Namely, if per capita energy consumption converges to a steady state in the long-run, deviations therefrom are transitory and will diminish eventually. On the contrary, if the movements of per capita energy consumption have characteristics of hysteresis, deviations therefrom caused by exogenous shock/innovation in the energy markets will have a permanent effect thereon (Narayan and Smyth, 2007; Hsu et al., 2008; Mishra et al., 2009; Lean and Smyth, 2009; Apergis et al., 2010a, 2010b; Aslan, 2011; Apergis and Tsoumas, 2012; Kum, 2012). The knowledge of whether the movements in per capita energy consumption have a transitory or a permanent effect is of great importance to policy makers (Shahbaz et al., 2012; Liu, 2013; Mishra and Smith, 2014; Pereira and Belbute, 2014). If energy consumption follows a stationary process, energy policy designated, for instance, to increase the efficiency of energy consumption will be effective even after an adverse energy shock. Namely, in that case, energy consumption will return to its trend path. On the contrary, if energy consumption is a unit root process, energy consumption is diverging, and an adverse shock to energy consumption may have permanent effects. As discussed in Le Pen and Sevi (2010), Shahbaz et al. (2012) or Smyth (2013), this knowledge also has several implications for modelling and forecasting energy as well as potentially more broadly for the other macroeconomic variables and alternative economic theories.

The convergence hypothesis is empirically testable by employing the unit root tests on per capita energy consumption. Finding evidence of a unit root provides evidence in favour of the unit root (also known as the hysteresis or no-convergence) hypothesis, while rejecting a unit

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root of the stationarity or convergence hypothesis. Testing for a unit root in energy variables that started in the second half of the 2000 s has become a new branch of research in energy economics (Narayan et al., 2010) and economics literature (Aslan, 2011) in general.

The majority of the preceding studies considered the issue of energy consumption convergence in the context of developed or Asia and Pacific region countries, in particular for a single country or panels of countries. Their empirical results are mixed; some of them indicate energy convergence, while the others indicate energy divergence for some countries or regions. Little attention has been devoted to this issue relative to Central, Eastern and Southeastern European (CESEE) countries (CESEE, e.g., Markandya et al., 2006; Zachman, 2008; Hajko, 2012; Teixeira et al., 2014) or a sub-national analysis (for Australia, see Narayan et al., 2010; for Russia, see Akhmedjonov and Lau, 2012; for the USA, see Apergis et al., 2010a, 2010b; Liu, 2013). Although the differences in the level of economic development and energy policy applied are being reduced by testing for energy convergence on the sub-national level, there is a research gap in the literature related to the absence of studies at this level, especially when it is about a small, open and energy-dependent economy. Narayan et al. (2010) highlight that this level is crucial for formulating policy implications since the dynamics of different regions of a country is maybe different, and hence the behaviour of energy consumption on a regional level can be potentially heterogeneous.

The main aim of this paper is to test the convergence hypothesis in per capita electricity consumption across 21 Croatian NUTS-3 regions in the period 2001–2013 by employing the panel unit root tests, and therefore to contribute to this analysis from the regional perspective. This study focuses on electricity consumption bearing in mind that different forms of energy consumption might exhibit different types of unit root behaviours (Lean and Smyth, 2010). Thereby, the focus will be given to the analysis of per capita electricity consumption in the residential and business sector. These sectors are large consumers of electricity, so it is important to uncover their behavioural patterns. The case of Croatia is also interesting since the previous studies on income convergence in Croatia, tested by using the beta and sigma approach, indicate divergence (absolute and conditional) in the 2000 s (see Drezgic, 2011; Borozan, 2015). Moreover, Croatia is a small, open, energy-dependent and energy import dependent post-transition EU country, where causation is likely to go from energy growth to economic growth (Borozan, 2013; Vlahinic and Jakovac, 2014), as gone in some CESEE countries (see Bildirici and Kayikci, 2012; Papiez and Smiech, 2013). Hence, it would be interesting to find out whether income and electricity convergence are going in the same direction. Understanding of the electricity consumption behavioural pattern by consumer's sector at the regional level presents a valuable basis for adequate energy and environmental policy design and implementation. Additionally, understanding energy consumption behaviour dynamics and pattern in Croatia may be valuable for other CESEE countries following a similar development path. Namely, as Gros and Suhrcke (2000) already observed, these countries are still specific compared with countries with similar income per capita, due to a higher share of energy use than expected on the basis of their income per capita, among others. So, some lessons and policy implications learned from Croatia's experience may be useful for them.

In the second half of the 2000 s, employing the panel unit root tests became more popular in testing for convergence than so-called β convergence. In this paper, to test for convergence across Croatian NUTS-3 regions, the Pesaran (2007) cross-section augmented Dickey-Fuller (CADF) and Im, Pesaran and Shin (CIPS) tests are used first. They allow for potential correlations across residuals of panel units. However, they do not take into account the possibilities of structural changes and their potential impacts on the convergence hypothesis. Moreover, they are designed to jointly test the null hypothesis of a unit root for all members of a panel. To mitigate these challenges, the Zivot and Andrews (1992; ZA) test and the Clemente-Montañés-Reyes (1998; CMR) test allowing for structural breaks(s) in each panel member are also used. Additionally, the paper explores the connections between the timing of the structural breaks and important economic and non-economic innovations. Detecting and understanding of the timing of the break is a matter of great policy interest.

Our empirical analysis leads to at least two important insights. First, energy demand management policies designed to reduce electricity consumption and improve energy efficiency should take into account that total electricity consumption is a heterogeneous phenomenon that exhibits different regional and sectoral patterns, and reacts differently to structural shocks. Hence, it should be considered on the disaggregated level and respect the regional differences. Second, energy policy may generate long-lasting effects even if it is applied for a limited amount of time. Hence, space and time for experimenting with alternative support mechanisms may be quite limited.

The remainder of the paper is organised as follows. Section 2 provides a brief overview of the literature. The methodology is explained in Section 3, whereas Section 4 gives and discusses the empirical results. The conclusions are given in the last section.

2. Literature review

Although there exists a sizeable literature on testing for a unit root in panels, only recently the empirical investigation of its existence in per capita energy consumption has become a field of interest to economists (Narayan and Smyth, 2007; Narayan et al., 2010; Aslan, 2011). As mentioned above, the results of these investigations are mixed, depending primarily on the method used to test for convergence, the time period and the group of countries considered. Unlike cross-national panel studies, the studies on energy consumption convergence at the national level are limited and particularly scarce at the sub-national level. A notable exception is the USA for which several studies aiming to test the unit root hypothesis on different energy consumption variables are done (Lean and Smyth, 2009; Gil-Alana et al., 2010; Apergis et al., 2010a, b; Apergis and Tsoumas, 2012; Liu, 2013). Their results are also mixed (for a review, see Smith, 2013). The same conclusion may be drawn when European countries come into question alone or within a group of other countries, as it can be seen from a brief survey of the literature that follows.

Le Pen and Sevi (2010) test for convergence of energy intensity for the group of 97 countries in the period 1971–2003 applying different unit root tests and a stationarity test. Their results reject the global convergence hypothesis but for European subgroups they find that non-convergence is less strongly rejected. Robinson (2007) analyses the extent to which electricity prices for nine European countries converged during the period 1978–2003 using β-convergence. His results support the convergence hypothesis for most of the sample countries. Kula et al. (2012) also argument the validity of this hypothesis for 21 OECD countries in the period 1960–2005 using the Lagrange Multiplier (LM) unit root test with structural breaks as well as Meng et al. (2013) for the period 1960–2010 who employ the standard LM and the residual augmented least squares LM unit root test. Likewise, Narayan and Smyth (2007) provide evidence on the panel stationarity in per capita energy consumption for 182 countries for the period 1980–2000 using the t-bar test developed by Im et al. in 2003. Shahbaz et al. (2013) uncover evidence of stationarity in per capita electricity consumption for 65 out of 67 countries using the LM unit root method in the period 1971–2010.

Employing panel regressions, Markandya et al. (2006) analyse the convergence of the energy intensity of 12 Eastern European countries to the EU15 average for the period 1992–2002. They find some evidence of convergence, and also that the countries with the fastest convergence rates are the Czech Republic, Bulgaria, Croatia and Turkey. However, employing principal component analysis of wholesale electricity prices in 2002–2006, Zachmann (2008) argues that there is enough evidence to reject the hypothesis of full European