RESIDENTIAL ENERGY CONSUMPTION AND ECONOMIC GROWTH IN THE TRANSITION ECONOMIES

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Abstract:

The Paris Agreement negotiated in the 2015 United Nations Climate Change Conference is a global agreement on the reduction of climate change mainly caused by GHGs, which comes into force in 2020. According to this Agreement, all participated countries have to reduce their emissions. In order to archive this objective, it is considered appropriate to apply energy saving policies in the residential sector, as residential buildings seem to be one of the most important sources of direct and indirect CO_2 emissions. Besides, energy consumption in the residential sector has an abundant potential for the implementation of energy saving policies.

Most countries of South-Eastern Europe and the former Soviet Union, which nowadays are considered as transition economies, have traditionally been high energy consumption countries with high energy intensity in the residential sector, especially from fossil fuels. This study investigates the relationship between economic growth and energy use in the residential sector in the transition economies.

The Environmental Kuznets Curve (EKC) hypothesis is tested by using panel data techniques, referred to 14 transition countries for 1995–2013 period. From the estimate results, the elasticities of the residential energy consumption per capita with respect to GDP per capita for each country and year are calculated.

The estimate results do not support the EKC hypothesis. Furthermore, the trend of the residential energy consumption elasticity with respect to per capita income is positive for all transition countries except Russia. The use of renewable energy and the adoption of energy efficiency measures are recommended.

Keywords: Environmental Kuznets Curve, economic growth, residential energy consumption, transition countries, panel data.

JEL codes: C23, O52, Q43, Q52

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1. Introduction

Recently, the Paris Climate Conference (COP21) agreement set out an action plan to avoid climate change by keeping the increase in global average temperatures to well below 2°C (Burleson, 2016). The COP21 (UNFCCC, 2015) contains the steps coming into force in 2020 whereby all countries are held responsible for taking action. Each country shall prepare, communicate and maintain, successive nationally determined contributions that it intends to achieve, in order to reduce their emissions. Thus, they should enhance their mitigation efforts, moving toward economy-wide emission reduction targets. To achieve these targets, the authorities should be capable of fully understanding and predicting how the environment is changing within their territories, and, depending on the findings, promote corresponding environmental policies to reduce emissions.

As Soytas et al. (2007) conclude, energy consumption is the main cause of CO_2 emissions, so controlling its growth is going to be crucial. However, while emissions growth could be controlled by reducing energy consumption, this reduction could also have negative effects on economic growth (Lotfalipour et al., 2010).

According to the *International Energy Outlook* Report (U.S. Energy Information Administration, 2013), energy demand in 2040 will be 56% higher than in 2010, emphasising that between 20% and 40% of the total energy will be consumed by buildings, both residential and commercial. Thus, energy use in residential buildings is one of the largest sources of direct and indirect CO_2 emissions (Estiri, 2015). Similarly, energy consumption in the residential sector is an area with great potential for implementing energy saving policies, which could be achieved not only through technical measures, but also by improving consumer behaviour (Ouyang & Hokao, 2009).

In short, to be able to develop environmental and energy efficiency policies it is necessary to completely understand the relationship between economic growth and energy consumption in general, and in the residential sector in particular, as increasing energy demand is at the centre of the environmental problem (Canadell et al., 2007). In this regard, the interest in this subject dates back to the pioneering study by Kraft and Kraft (1978), which examined this relationship in the case of the United States.

Most countries of South-Eastern Europe and the former Soviet Union, which nowadays are considered as transition economies, have traditionally been high energy consumption countries with high energy intensity in the residential sector, especially from fossil fuels. Moreover, as stated by Cornillie and Fankhauser (2004), when these economies collapsed after the Soviet Union breakup, energy consumption did not decrease proportionately, and the energy intensity in the residential sector increased further from an already high level. Therefore, the analysis of the relationship between residential energy consumption and economic growth in this group of countries is especially relevant to compliance with the environmental agreements.

However, there have been very few empirical studies on this relationship for transition countries. According to the review by Joo et al. (2015), currently, only the study by Apergis and Payne (2009) has examined the relationship between energy consumption and economic growth in eleven countries of the Commonwealth of Independent States in the 1991-2005 period. Nevertheless, additionally, other studies related to electricity consumption can be also found. Among them, the study by Bildirici and Kayikci (2012) refers to the countries of the former Soviet Union. The study by Acaravci and Ozturk (2010) focuses on the causal relationship between electricity consumption and economic growth in 15 European transition countries during the period 1990-2006. Finally, Wolde-Rufael (2014) analyses the same causal relationship, extending the study period from 1975 to 2010, obtaining different results.

Following on from these previous studies, the aim of this paper is to analyse the relationship between economic growth and energy consumption in the residential sectors of the transition economies. For this, the Environmental Kuznets Curve (EKC) is tested by using a panel data of 14 economies in transition in the period 1995-2013. From the estimate results, the elasticities of the residential energy consumption per capita (RECpc) with respect to GDP per capita (GDPpc), for each country and year, are calculated according to Pablo-Romero and Sánchez-Braza (2015).

The EKC hypothesis refers to the inverted U shape relationship between the level of environmental degradation and the economic development level (usually measured by per capita income). According to this hypothesis, environmental degradation increases during the early stages of economic growth, but from a certain income level (turning point), higher economic growth would be accompanied by improvements in environmental quality. Therefore, economic growth could be a solution to the environmental problem, rather than its source (Rothman & De Bruyn, 1998).

The validity of the EKC hypothesis has been extensively tested by using panel data techniques (studies referring to a group of countries), or alternatively using time series techniques (studies referring to specific countries. In this regard, the papers by Kaika and Zervas (2013a, 2013b) and Stern (2014), among others, carried out a systematic review of these previous studies. In most of them, total CO_2 emissions is used as the indicator of environmental degradation, but also the total energy consumption is used in numerous studies. Among the latter may be mentioned the studies by Cole et al. (1997), Luzzati and Orsini (2009) and Pablo-Romero and De Jesús (2016).

Fewer studies refer to emissions or energy consumption at sectoral levels. Some of them test the EKC referring to the industry sector (see Fu & Zhang, 2015; Wang et al., 2014), to the transport sector (such as Abdallah et al., 2013; Azlina et al., 2014; Shahbaz et al., 2015) and to the agricultural sector (recently, for example, Liutao, 2016). In parallel with these works, the study by Bohne et al. (2016), regarding eight different climatic zones, and the study by Yin et al. (2015) in China, estimate the EKC referring to the energy consumption of residential buildings. Following these recent studies, the EKC referring to the residential energy consumption in transition countries is tested in this study.

2. Methodology

The general specification model for testing the EKCs may be expressed by the following equation:

$$E_{it} = A_{it} + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + e_{it} \quad [1]$$

where E is a measure of environmental pressure, in this study being the RECpc in natural logarithms. Y is the independent variable of GDPpc in natural logarithms. A is the sum of time and country effects. β_1, β_2 and β_3 are the parameters of the function to be estimated. e is a random error term. i is equal to 1, 2, etc., to 14 countries of the sample, and finally t is the time in years from 1995 to 2013.

β coefficients values inform about the form of relationship between the variables of RECpc and GDPpc. According to Dinda (2004), the EKC hypothesis is verified and presents the classic inverted U shape if β_1>0, β_2<0 and if it is applicable β_3≤0. Similarly, if β_1>0, β_2>0 and β_3<0, the curve may present the U shape from a certain Y value which depends on the β coefficients values. Alternatively, if β_1>0, β_2<0 and β_3>0, then the curve presents an N shape.

Equation [1] has been estimated in previous studies by including and excluding the cubic term of the variable Y. However, according to Luzzati and Orsini (2009), estimates including the cubic term give greater flexibility to the model. In this study, both specifications have been tested and compared.

Additionally, in previous studies, other variables that may affect E have often been included in the EKC specifications, in order to best fit the available data and the overall objective of the study (Kaika & Zervas, 2013a). Two additional control variables have been included in [1] for a better model specification. Firstly, a control variable representing the percentage of population living in rural areas has been included. This control variable measures the possible effect of living in rural and urban areas on the residential energy consumption. In this regard, previous studies consider that residential energy use may be affected by the rural-urban area dichotomy (Heinonen & Junnila, 2014; Wiedenhofer et al., 2013). Secondly, the density of the total population has also been included. Various previous studies argue that compact urban forms would reduce energy consumption in buildings (Steemers, 2003), while other authors indicate that lower energy consumption would be achieved by decentralised concentration (Holden & Norland, 2005). Similarly, Dujardin et al. (2014) find that while dense urban settlements are more efficient, some rural settlements, characterised by a low density, also have good performances.

Before estimating the EKC hypothesis it is necessary to perform the econometric analysis of the data properties. Firstly, multicollinearity among the squared and cubic variables has been analysed, as this problem among variables has been noted in previous studies, such as in Narayan and Narayan (2010). In order to analyse the potential problems of multicollinearity, the variance inflation factor (VIF) statistic is calculated. The VIF statistic measures the extent to which the variance of the estimated regression coefficients has been inflated or over-estimated, compared with a context in which the explanatory variables are not linearly related. The multicollinearity problem exists if any VIF statistic value is greater than 10 (Kleinbaum et al., 1988). Nevertheless, a more stringent criterion recommends a maximum VIF of 5 (Pablo-Romero et al., 2015; Sánchez-Braza & Pablo-Romero, 2014). As shown in Table 2 in the Data Section, the obtained VIF statistics show values much higher than 10. Therefore, in order to mitigate this problem, the variables have been converted to deviations from the geometric mean of the sample, which made the multicollinearity problem between variables disappear. So, it is possible to rewrite equation [1] as follows:

$$\overline{E}_{it} = \delta_t + \alpha_i + \beta_1 \overline{Y}_{it} + \beta_2 \overline{Y}_{it}^2 + \beta_3 \overline{Y}_{it}^3 + e_{it} + \varphi_1 \overline{C}_{1it} + \varphi_2 \overline{C}_{2it} \qquad [2]$$

where the upper dash over variables represents that they are converted to deviations from the geometric mean of the sample. C_1 and C_2 are the control variables that have been added to the model, i.e., the percentage of the population living in rural areas and the density of the total population, respectively.

Secondly, the stochastic nature and properties of the series have been analysed in order to determine the best method to estimate [2] and avoid spurious estimates (Stern, 2014). Initially, the test proposed by Pesaran (2004) is applied to contrast the null hypothesis of cross-sectional independence. Next, depending on the previous Pesaran test results, the IPS unit root test by Im et al. (2003) is performed if the series do not show cross-sectional dependence, while the CIPS unit root test (cross-sectionally augmented IPS) by Pesaran (2007) is performed if the series do present this dependence problem. In both tests, the null hypothesis considers that all units have panel unit root, against the alternative hypothesis that at least one of them is stationary. Finally, two panel cointegration tests are used to test the existence of a structural long-run relationship among the variables: The Westerlund (2007) test and the Pedroni (1999) test. The Westerlund (2007) test performs four statistics which are enough to accommodate cross-sectional dependence. The Gt and Ga statistics test whether cointegration exists for at least one individual, while the Pt and Pa statistics test whether cointegration exists for the panel in total. Additionally, the test proposed by Pedroni (1999) calculates seven different statistics to test cointegration in panel data.

Taking into account the results of the previous tests performed on the data series, equation [2] is estimated both in levels and in first differences.

Finally, from the estimate results, the elasticities of RECpc with respect to GDPpc have been calculated for each country and year, as follows:

$$Ela_{it} = \beta_1 + 2\beta_2 \overline{Y}_{it} + 3\beta_3 \overline{Y}_{it}^2 \qquad [3]$$

The elasticity in this case is the derivative of function [2], which allows the percentage change of per capita income in relation to per capita residential energy consumption to be defined.

3. Data

3.1. *Data sources*

This study uses a panel data of 14 countries considered as economies in transition over the period 1995-2013. The annual report published by The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (United Nations, 2016) classifies 17 countries as economies in transition. Nevertheless, this paper only considers 14 of the 17 transition countries included in the report, given the unavailability of some data for Turkmenistan, the Republic of Macedonia and Montenegro. Therefore, the countries included in the analysis are the following: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, the Republic of Moldova, Russian Federation, Serbia, Tajikistan, Ukraine and Uzbekistan.

Residential energy consumption data come from the International Energy Agency (IEA, 2016), which offers energy data for its member countries as well as for a wide range of non-member countries. Total final energy consumption per capita by the residential sector is considered. Data are expressed in natural logarithms of kilograms of oil equivalent consumption by the residential sector per capita.

The rest of the data (*Y*, total population, rural population and density) come from the World Bank Development Indicators (World Bank, 2016). Total population is used to convert residential energy consumption and income expressed in absolute terms in per capita terms. *Y* is expressed in natural logarithms of GDP in constant 2005 U.S. Dollars per capita. Population density is measured as the natural logarithm of persons per square kilometre. Finally, rural population is expressed as percentage of total population.

3.2. *Descriptive analysis*

Table 1 presents the main descriptive statistics of the variables used to estimate the EKC. The *between statistics* refer to the average data values of each country, while the *within statistics* refer to intra group values over time for each country, and to the variation from each country's average. Table 1 shows that the standard deviation of the data across countries is higher than across time for all variables during the considered period.

Table 1. Descriptive statistics (1995-2013).

Variable		Mean	Std. Dev.	Min.	Max.	Observations
RECpc (E) (in logs)	overall	5.419	0.923	3.362	6.897	N = 266
	between		0.887	3.601	6.755	n = 14
	within		0.342	3.882	6.586	T = 19
GDPpc (Y) (in logs)	overall	7.303	0.866	5.325	8.842	N = 266
	between		0.821	5.742	8.491	n = 14
	within		0.348	5.976	8.095	T = 19
% of rural population (C_1)	overall	48.440	13.864	24.123	73.6	N = 266
	between		14.255	26.501	73.167	n = 14
	within		1.680	39.254	55.726	T = 19
Density (C_2) (in logs)	overall	3.959	0.910	1.705	4.850	N = 266
	between		0.941	1.750	4.832	n = 14
	within		0.048	3.806	4.145	T = 19

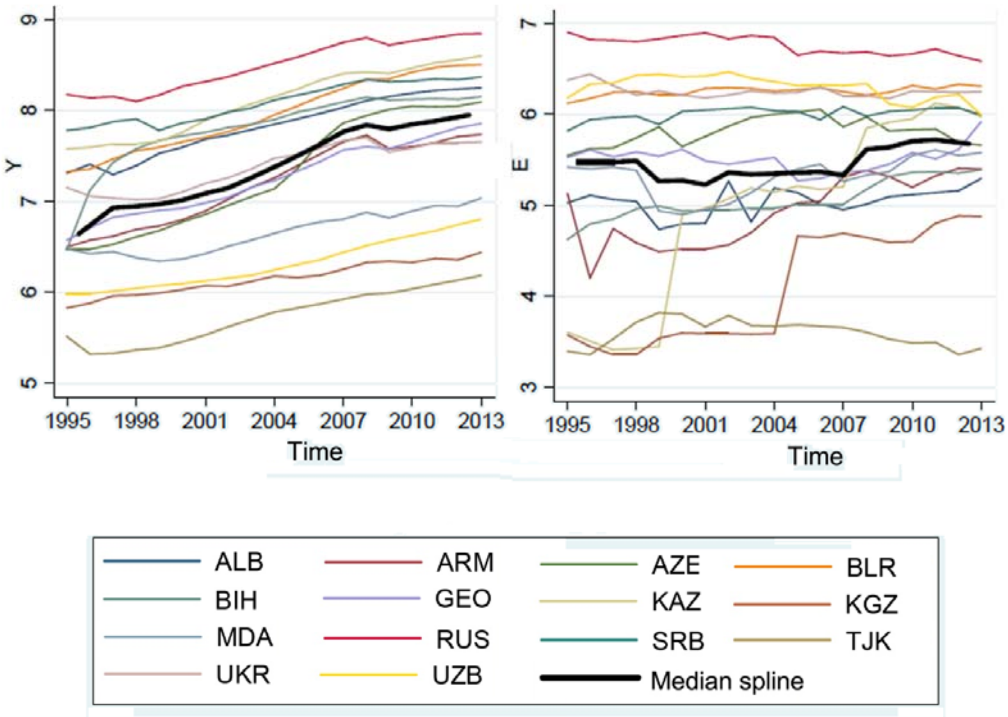
Source: Own production.

Figure 1 shows the evolution of GDPpc in logs (left graph) and RECpc in logs (right graph) of the 14 analysed transition economies over the period 1995-2013. The data for each country are represented individually by a coloured line. Additionally, the median spline of all countries for each year is represented by a black line.

The evolution of GDPpc shows a positive trend over the analysed period. The countries with the highest GDPpc are the Russian Federation, Kazakhstan, Belarus, Serbia, Albania and Bosnia and Herzegovina. On the other hand, Ukraine, the Republic of Moldova, Kyrgyzstan, Uzbekistan and Tajikistan represent a below average GDPpc level. Noticeable differences in GDPpc values may be observed between countries. On average, this group of countries showed a growth rate equal to 5.39% during the analysed period. Bosnia and Herzegovina, with 10.67%, shows the highest growth rate of the sample, while Ukraine has the lowest (2.87%).

The evolution of RECpc generally shows a stable trend during the analysed period. This stability can particularly be seen in countries with the highest level of residential energy consumption: Ukraine, Belarus, Uzbekistan, Serbia and Azerbaijan, which maintain almost the same level of RECpc over time. Furthermore, Russia even shows a slight decrease. The opposite occurs in some countries with low RECpc, such as in Kazakhstan and Kyrgyzstan. These countries show a significant increase in this consumption in 1999 and 2004 respectively. Armenia has also been increasing its RECpc level since 1996.

Figure 1. Evolution of GDPpc and RESpc (1995-2013).



Source: Own production from IEA (2016) and World Bank (2016).

3.3. *Econometric analysis of the data properties*

Table 2 shows the values of the VIF statistic, which calculates the multicollinearity of the variables used in [2] when these are expressed through its values and in terms of deviations from their geometric mean. As shown in Table 2, the transformation of variables significantly reduces the VIF statistic values. Therefore, the multicollinearity problem disappears when variables are expressed in terms of deviations from the geometric mean.

Table 2. Analysis of multicollinearity.

Variable	VIF variables	VIF deviations to the geometric mean
Y	36704.73	4.19
Y^2	150948.49	2.07
Y^3	39394.17	4.34
C_1	2.40	2.40
C_2	1.63	1.63

Source: Own production.

Table 3 shows the results of the cross-sectional dependence test proposed by Pesaran (2004). The results show that at a 1% significance level the null hypothesis of cross-sectional independence is rejected in the case of the variable *Y*, as well as its squared and cubic term. It also shows that for all other variables, it is not possible to reject the null hypothesis.

Table 3. Cross-sectional dependence test.

Variable	CD-test
Y	39.31 ***
Y^2	39.42 ***
Y^3	39.51 ***
C_1	1.40
C_2	-0.07

Source: Own production.

Table 4 shows the results of the IPS unit root test applied to the variables without cross-sectional dependence problems, such as residential energy consumption, density and rural population. Additionally, Table 5 shows the results of the CIPS unit root test applied to the variables related to GDP. Here, the cross-dependence problem is taken into account. Both tests are applied to the variables in levels, first differences with constant and with constant and trend. In order to determine the delay of the CADF regressions underlying the model, the ADF test was carried out for each individual of the sample. The optimal delay for each individual is determined according to the Bayesian Information Criterion (BIC).

Table 4. IPS unit root test.

Variables	Levels		First differences	
	Constant	Constant and trend	Constant	Constant and trend
E	-0.635	-1.181	-13.599***	-12.724***
(Avg.lag)	(0.14)	(0.50)	(0.21)	(0.21)
C_1	-1.859**	-5.875***	-2.274***	-7.758***
(Avg.lag)	(1.57)	(1.43)	(0.93)	(0.93)
C_2	1.964	1.165	-2.881***	-2.280***
(Avg.lag)	(1.57)	(1.71)	(0.50)	(0.50)

Source: Own production.

Note: t-bar statistics ***denotes significant level at 1%, **at 5% and *at 10%. Avg. lag (in bracket) denotes the average lag length of the underlying ADF test regressions

Table 5. CIPS unit root test in the presence of cross-sectional dependence.

Variables	Levels		First differences	
	Constant	Constant and trend	Constant	Constant and trend
Y	-2.174	-2.290	-3.019***	-3.055***
(Avg.lag)	(1.785)	(1.785)	(0.642)	(0.642)
Y^2	-1.225	-2.277	-2.740***	-2.925***
(Avg.lag)	(1.714)	(1.714)	(0.571)	(0.571)
Y^3	-1.967	-2.441	-3.037***	-3.050***
(Avg.lag)	(1.714)	(1.714)	(0.571)	(0.571)

Source: Own production.

Note: t-bar statistics *** denotes significant level at 1%, ** at 5% and * at 10%. Avg. lag (in bracket) denotes the average lag length of the underlying ADF test regressions.

Table 6 shows the results of the cointegration test proposed by Pedroni (1999, 2004). The results show that all indicators, except one (Adf-panel), reject the null hypothesis of no cointegration of variables at a 1% significance level. On the other hand, Table 7 shows the results of the cointegration test proposed by Westerlund (2007), which can be applied under the assumption of dependence between units of cross sections through a bootstrapping process (400 replicates). Considering the robust Z-value, two statistics (Gt and Pt) allow rejection of the null hypothesis of no cointegration between the variables of the model, while the other two (Ga and Pa) show evidence to the contrary.

Thus, it may be concluded that there is some evidence for cointegration of variables, making it convenient to estimate[2] in levels. However, since there are three statistics that show evidence against this cointegration, estimates in first differences were also made.

Table 6. Pedroni´s cointegration test.

Statistics	Panel statistics	Group statistics
Y	-2.839	-
Rho	2.397	3.74
T	-8.603	-10.49
Adf	1.288	2.332

Source: Own production.

Table 7. Westerlund´s cointegration test.

Statistics	Z-value
Gt	-7.243***
Ga	7.288
Pt	-3.683***
Pa	6.050

Source: Own production.

Note: The test is performed on a regression with constant and trend. BIC is used to determine the lag length. Kernel band is determined according to (T/100) 2/9. *** denotes significant level at 1%, ** at 5% and * at 10%.

4. Results and discussion

4.1. *Estimate results and elasticity values*

Table 8 shows the estimate results of equation [2] for the 14 countries in transition during the period 1995-2013. All estimates were performed by the method of Feasible Generalized Least Squares in the presence of heteroscedasticity, autocorrelation and contemporaneous correlation. The null hypothesis of homoscedasticity according to the modified Wald test, as well as the null hypothesis of no autocorrelation according to the Wooldridge (2002) test and the null hypothesis of cross-sectional independence of the Pesaran (2004) test are rejected in all cases.

Table 8. Results of estimates.

	Levels		First differences	
	Squared	Cubic	Squared	Cubic
β_1	0.221*** (0.061)	0.243*** (0.054)	0.247*** (0.062)	0.273*** (0.061)
β_2	0.118*** (0.031)	0.110** (0.047)	0.112*** (0.041)	0.052 (0.040)
β_3	-	-0.070*** (0.022)	-	-0.054*** (0.027)
φ_1	0. 041*** (0. 011)	0.026** (0.013)	0.0009*** (0.0002)	0.0006** (0.0002)
φ_2	-	0.987** (0.393)	-	-

Source: Own production.

Note: Standard errors are shown in parenthesis, *** denotes significant level at 1%, ** at 5% and * at 10%.

The previous econometric analysis of the data properties show that variables are I(1), as they are stationary in first differences and non-stationary in levels. Similarly, the null hypothesis of no co-integration cannot be rejected. Therefore, [2] has been estimated in levels. However, since there are three statistics that do not provide evidence of cointegration, [2] has also been estimated in first differences in order to avoid spurious estimates.

The estimates in levels were performed with and without the cubic term of the variable *Y*, including time and individual dummies. The estimates in first differences were also performed by including, or not, the cubic term of *Y* and including time dummies.

Table 8 shows that both estimates, in levels and first differences, are quite similar. Thus, the results of estimates show that the coefficient β_1 is significant and positive in all specifications, which means that the elasticity of the RECpc with respect to GDPpc is positive in the central point of the sample. All estimates show that this value is around

0.25. In addition, all estimates show that the β_2 coefficient is positive, being significant in all specifications except when the cubic term is included in first differences. In the last estimate, removing the squared variable does not appreciably change the value and significance of the rest of the coefficients, with β_1 then being positive and β_3 negative. Finally, when the cubic term of GDPpc is included, the coefficient β_3 is negative. It also should be noted that φ_1, the C_1 estimate coefficient (rural population percentage), is significant and positive, while φ_2, the C_2 estimate coefficient (population density), is significant and positive only when the function is estimated in levels and the cubic term of GDPpc is included. Therefore, the C_2 variable has been removed from the estimates when it is not significant, which does not notably affect the other coefficients estimates.

These results do not support the U inverted form that confirms the EKC hypothesis for the residential sector in transition countries in the period considered. Estimates not including the GDPpc cubic term show that $\beta_1>0$ and $\beta_2>0$, which means that an increase in GDPpc leads to an increase in RECpc. Similarly, estimates including the cubic term also show positive values for both parameters. Nevertheless, as $\beta_3<0$, the EKC is supported from a certain GDPpc level. In order to calculate whether the EKC turning point has been reached, it is adequate to calculate the elasticity values for each GDPpc level. The turning point is reached when the elasticity is equal to zero, and changes from positive to negative values.

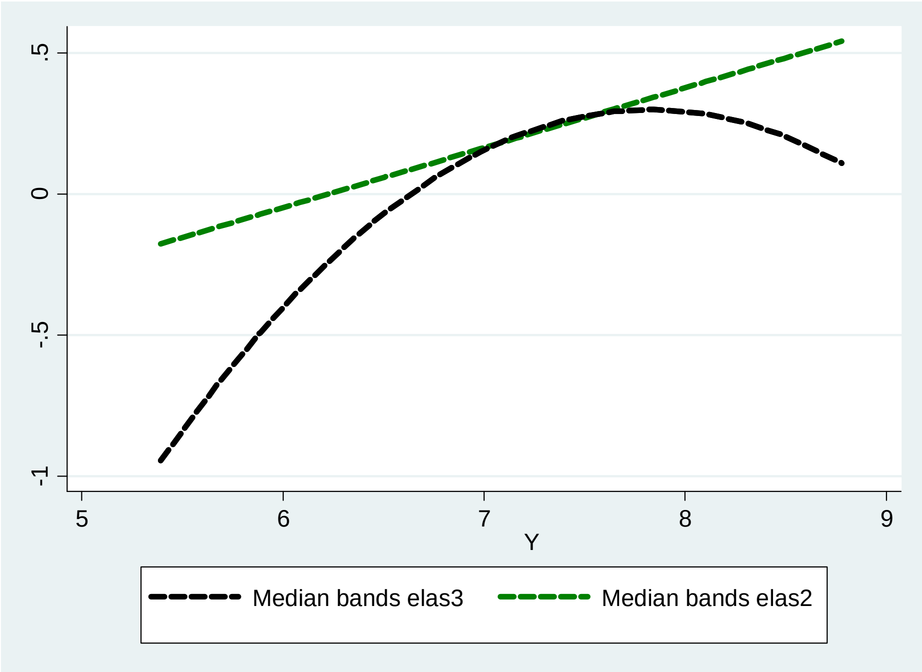
From the β_1, β_2 and β_3 estimated values in levels (Table 8), and in accordance with [3], the elasticities of RECpc with respect to GDPpc were calculated for the quadratic (*Ela*2) and cubic function (*Ela*3), as follows:

a) $$Ela2 = 0.221 + 2*0.118\,\overline{Y}_{it}$$

b) $$Ela3 = 0.243 + 2*0.110\,\overline{Y}_{it} + 3*0.070\,\beta_3\overline{Y}_{it}^{2}$$

In the case of the quadratic function, Figure 2 shows that the RECpc elasticity with respect to GDPpc increases with GDPpc. It is also shown that for lower levels of GDPpc, this elasticity is negative, becoming positive for high levels of GDPpc.

Figure 2. Estimated elasticity of RESpc with respect to GDPpc.



Source: Own elaboration

In the case of the cubic function, the elasticity shows an inverted-U shape. Initially, the elasticity is negative and increases with GDPpc, becoming positive from a GDPpc value close to 6.7 (in logs). This result indicates that the increases in GDPpc levels have reduced the RECpc when GDPpc levels are low, thereby improving environmental quality. Similar results are found in Pablo-Romero and De Jesús (2016) when referring to energy consumption in the Latin American countries. Additionally, this conclusion is in line with Ozcan (2013) and Wang et al. (2011), who find that pollution levels decrease as a country develops when the development level is low, in Middle East countries and in Chinese provinces, respectively.

However, from a GDPpc value equal to 6.7, the elasticity becomes positive. Therefore, GDPpc increases bring about a positive and growing trend in RECpc. Eventually, for higher incomes, Figure 2 shows that the elasticity begins to decrease, although always positive. That is to say, the EKC turning point is not reached. Thus, the residential energy consumption continues increasing with GDPpc, but at a slower rate.

Consequently, the economic growth of transition countries is not likely to solve the environmental problems caused by the residential energy consumption. Therefore, it is necessary to establish energy saving policies by setting out energy efficiency measures in households and buildings, and promote the use of renewable energy in order to reduce environmental problems.

It is worth noting that most of the transition countries have notable energy saving potential in district heating sectors. As stated in IEA (2015), a high share of the energy used in buildings comes from district heat. The Russian Federation is the country with the largest district heating system in the world, but this system also plays an important role in Belarus, Kazakhstan, Kyrgyzstan, the Republic of Moldova, Serbia, Ukraine, Uzbekistan and Tajikistan. However, this energy is produced, distributed and consumed very inefficiently. Therefore, the efficiency of these systems is still quite low. For example, in Russia efficiency is around 73% compared to 90% in the countries of northern Europe. Thus, although some countries have begun to promote initiatives to improve the efficiency of district heating systems, as noted in Berardi (2016), much more is needed. In this regard, the IEA (2015) report highlights that the key to maximising the energy saving potential lies in fundamental sector reforms related to requiring the system operator to perform system upgrades and rehabilitation, increase tariffs to full cost and remove subsidies which distort price signals, inducing large inefficiencies into the way in which energy is consumed. Nevertheless, although it may be appropriate to remove subsides, it may also be necessary, as stated in Bouznit and Pablo-Romero (2016), to apply some effective compensatory schemes, such as protecting low income groups by maintaining subsidy schemes for the most vulnerable.

Numerous studies, such as UNDP (2014a, 2014b) and Nabiyeva (2015), give evidence of the enormous potential for power generation from renewable energies in these transition economies. The use of these energies, already less developed in these countries, could reduce the residential energy dependence problems observed in some countries (as commented before), while increasing less pollutant energy consumption in all of them. Additionally, some of these renewable energies could be especially relevant to distant rural areas of the region with limited access to the grid and conventional energy sources.

4.2. *Evolution of RECpc elasticities by countries*

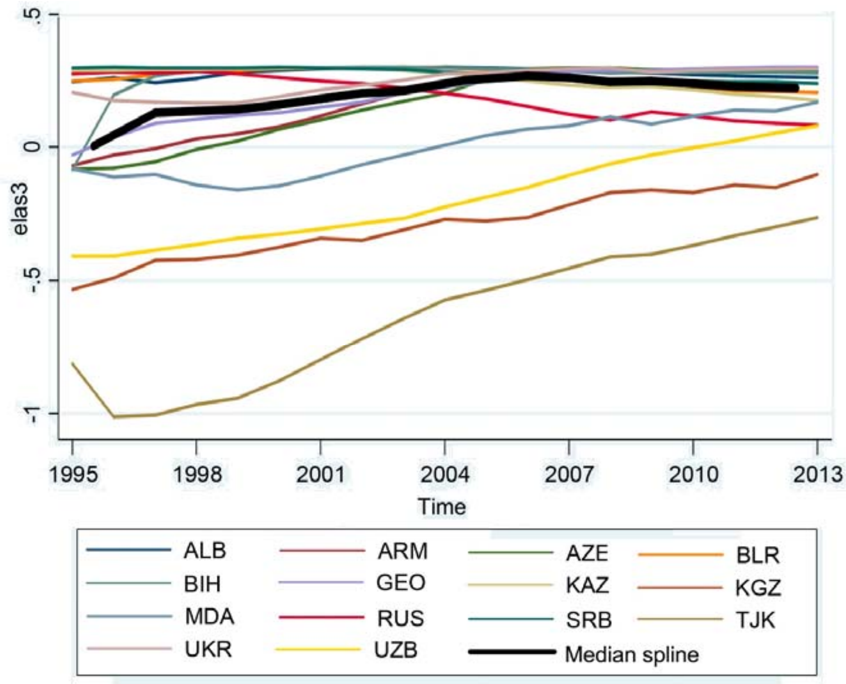
Figure 3 shows the evolution of the elasticity of RECpc with respect to GDPpc by countries, when Ela3 values are used to calculate them. As shown in Figure 3, the elasticity values are not constant over the analysed period. The black line represents the trend of the elasticity median spline. This trend was increasing throughout the analysed period until the beginning of the financial crisis in 2007. From that year, the trend was slightly decreasing.

Figure 3 shows notable differences among the transition countries RECpc elasticities values and trends. Kazakhstan, Belarus, Albania, Serbia and Bosnia and Herzegovina, have positive elasticities, around 0.4, their trend being almost constant or slightly decreasing from 2005. Russia also has positive and decreasing elasticity values through the period, its decreasing trend being much more evident. Meanwhile, the elasticities of the Caucasus countries, such as Armenia, Azerbaijan and Georgia are positive, with a growing trend. The Ukraine also shows positive values and a growing trend, but the former have lower elasticities (near zero) at the start of the period. Finally, the Republic of Moldova, Tajikistan, Kyrgyzstan and Uzbekistan have very low or even negative elasticity values throughout the whole period. Nevertheless, these countries show noticeable positive trends. At the end of the period, the Republic of Moldova and Tajikistan ended up having positive elasticities.

The notable elasticity differences among countries in trends and values, makes it interesting to discuss the situation of each of them. Thus, among the countries with higher positive elasticities and slightly decreasing trends, Kazakhstan stands out as being one of the countries of Central Asia that has the highest RECpc elasticity. As summarised in Gómez et al. (2014), the high energy intensity of Kazakhstan is mostly due to the excessive energy demand of buildings, mainly for heating and water heating in the household sector. From this aspect, promoting the use of more efficient heating systems is necessary.

In the case of Belarus, it is worth noting its high energy dependence. Raslavičius (2012) concludes that a strategic task for the Belarusian economy is to reduce energy imports (specifically, natural gas from Russia), bioenergy being one of the most important renewable energy sources for the future energy supply in this country, especially for the residential sector. Also, Urge-Vorsatz et al. (2013) underline that energy dependence is one of the challenges of energy use in the household sector.

Figure 3. Elasticity of RESpc with respect to GDPpc for 14 transition countries (1995-2013).



Source: Own elaboration

The situation of Balkan countries, such as Serbia and Bosnia and Herzegovina, is quite similar. According to Tešić et al. (2011), Serbian energy imports are increasing over recent years and its main energy reserves are represented by various types of coal, dominated by more than 92% of low-quality lignite coal, which is partly used for residential use, as stated in Karakosta et al. (2012). The shift from coal to cleaner and more efficient energies, without incurring increasing energy imports, is a main challenge. In this regard, Serbia and Bosnia and Herzegovina, as potential members of the European Union, must meet the requirements regarding the proportions of renewable energy usage. The use of renewable energies could be a solution to reduce coal usage in the residential sector, either through the direct use of renewable energy sources, or through increasing electricity generated from clean energy consumption. Up to now, hydroelectric power is the only form of renewable energy that has been developed in these countries, although not all its great potential has been exploited.

Meanwhile, in the Caucasus countries (Armenia, Azerbaijan and Georgia), RECpc elasticities are positive with a growing trend. In this region, buildings represent about 50% of final energy consumption, which is a great opportunity to achieve energy savings of around 20-40% (REN21, 2015). In that regard, the IEA (2015) recommended strengthening local and regional initiatives for energy savings in order to implement more efficient practices for electricity and heating.

On the other hand, as has been noted previously, some countries have a low or negative elasticity. Negative values of the elasticities of these countries indicate that economic growth causes a decrease in residential energy consumption. This decrease could be explained, in line with previous studies, by the low level of economic development of these countries, as its per capita income is below the average value of the sample (see Figure 2). These countries suffer from lack of investment, with their energy sector being characterised by old infrastructure and high losses (IEA, 2015). Therefore, while these countries are having higher income levels, they are investing in the energy sector, reducing the losses, and therefore becoming less polluting. Nevertheless, it could be expected that RECpc will start to grow when these countries become more developed, hence the implementation of some regulatory schemes related to buildings would be recommended as the countries start growing. These countries are already starting to implement some energy efficiency measures, such as the Law on Energy Conservation and Energy Efficiency in Buildings adopted in 2013 in Kyrgyzstan.

Finally, it is worth noting the special case of the Russian Federation. The elasticity of its RECpc has shown a decreasing trend since 2000. Zhang (2011) notes that during 2001-2008, the Russian Federation has achieved a considerable reduction in energy intensity, due to two major factors. Firstly, owing to the oil and gas price hikes, Russia's fiscal revenue gained a tremendous increase, which provided a solid capital foundation for the advances in energy technology investments. Secondly, it is highly related to structural changes, in particular to the increase of the share of the service sector compared to previous decades. In this regard, Cornillie and Fankhauser (2004) point out that the decline in energy intensity, both industrial and residential, which took place during this transition period, may be associated with the market reforms and structural changes carried out. Thus, this energy consumption decline may be considered as energy efficiency improvements that led to notable environmental benefits.

5. Conclusions

The Paris Agreement, negotiated in the 2015 United Nations Climate Change Conference, is a global agreement on the reduction of climate change mainly caused by GHGs, and comes into force in 2020. According to this Agreement, all participating countries have to reduce their emissions. In order to achieve this objective, it is considered appropriate to apply energy saving policies in the residential sector, as residential buildings seem to be one of the most important sources of direct and indirect CO_2 emissions. In addition, energy consumption in the residential sector has an abundant potential for the implementation of energy saving policies.

This paper analyses the relationship between economic growth and energy consumption in the residential sector in 14 transition economies by testing the EKC hypothesis. A panel data referring to 14 transition countries during the period from 1995 to 2013 is used. Furthermore, from the results of the estimates, the elasticities of this energy consumption with respect to per capita income are calculated for each country and each year.

The estimate results show that the elasticity of RECpc, with respect to GDPpc in the central point of the sample, is significant and positive, with a value around 0.25. Moreover, it can be concluded that the estimate results do not support the inverted U form that sustains the EKC hypothesis. Nevertheless, as the coefficients related to GDPpc and squared GDPpc terms are positives, and the coefficient related to the cubic GDPpc term is negative, the EKC is supported from a certain GDPpc level. However, this level has not been reached in any country. Therefore, economic growth in the transition countries is not likely to solve the environmental problems, but continue to make them worse. Therefore, it is necessary to develop the use of renewable energy and to establish energy saving policies in this group of countries. In addition, the RECpc elasticities are not constant over time. The general trend of these elasticities for all countries is positive, throughout the analysed period, until the beginning of the financial crisis in 2007. From that year, a slight decrease is shown, which may be related to this crisis and to the application of some energy efficiency measures in some countries.

Similarly, the values of the elasticities differ among countries. Kazakhstan, Belarus, Albania, Serbia and Bosnia and Herzegovina have growing positive elasticities which tend to slightly decrease from 2005. At the same time, these countries have large reserves of renewable energy, the development of which is essential for future sustainable economic growth. Meanwhile, the elasticities of Armenia, Azerbaijan, Georgia and Ukraine are positive with a growing trend. In this region, buildings represent about 50% of final energy consumption, which is a great opportunity to achieve energy savings. Moldova and countries of Central Asia, such as Kyrgyzstan, Tajikistan and Uzbekistan, are among the countries with negative elasticity values due to their low level of economic development. However, the trend of these elasticities is growing, which means that without the establishment of appropriate energy policies, subsequent economic growth will begin to generate an increase in residential energy consumption. Finally, the Russian Federation represents a special case, being the only country in the sample whose RECpc elasticity trend is markedly decreasing in recent years, which may be related to investments in energy saving technology and the implementation of some initiatives to improve efficiency of district heating systems. However, much remains to be done, as this efficiency is still relatively low, compared with other European countries.

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