European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

EUI WORKING PAPERS

RSCAS 2014/03
Robert Schuman Centre for Advanced Studies
Global Governance Programme-74

Former Soviet Union Countries and European Union: Overcoming the Energy Efficiency Gap

Olga Podkorytova and Yulia Raskina

European University Institute
Robert Schuman Centre for Advanced Studies
Global Governance Programme

Former Soviet Union Countries and European Union: Overcoming the Energy Efficiency Gap

Olga Podkorytova and Yulia Raskina

EUI Working Paper **RSCAS** 2014/03

ISSN 1028-3625

Printed in Italy, January 2014
European University Institute
Badia Fiesolana
I – 50014 San Domenico di Fiesole (FI)
Italy
www.eui.eu/RSCAS/Publications/
www.eui.eu
cadmus.eui.eu

Robert Schuman Centre for Advanced Studies

The Robert Schuman Centre for Advanced Studies (RSCAS), created in 1992 and directed by Brigid Laffan since September 2013, aims to develop inter-disciplinary and comparative research and to promote work on the major issues facing the process of integration and European society.

The Centre is home to a large post-doctoral programme and hosts major research programmes and projects, and a range of working groups and *ad hoc* initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration and the expanding membership of the European Union.

Details of the research of the Centre can be found on:
http://www.eui.eu/RSCAS/Research/

Research publications take the form of Working Papers, Policy Papers, Distinguished Lectures and books. Most of these are also available on the RSCAS website:
http://www.eui.eu/RSCAS/Publications/

The Global Governance Programme at the EUI

The Global Governance Programme (GGP) is research turned into action. It provides a European setting to conduct research at the highest level and promote synergies between the worlds of research and policy-making, to generate ideas and identify creative and innovative solutions to global challenges.

The GGP comprises three core dimensions: research, policy and training. Diverse global governance issues are investigated in *research* strands and projects coordinated by senior scholars, both from the EUI and from other internationally recognized top institutions. The *policy* dimension is developed throughout the programme, but is highlighted in the GGP High-Level Policy Seminars, which bring together policy-makers and academics at the highest level to discuss issues of current global importance.The Academy of Global Governance (AGG) is a unique executive *training* programme where theory and “real world” experience meet. Young executives, policy makers, diplomats, officials, private sector professionals and junior academics, have the opportunity to meet, share views and debate with leading academics, top-level officials, heads of international organisations and senior executives, on topical issues relating to governance.

For more information:
http://globalgovernanceprogramme.eui.eu

Abstract

This paper evaluates convergence of energy intensity for the former USSR countries during 1995-2010. We divide these countries into three clubs and show convergence in income and in energy intensity for each club. We also demonstrate that rate of convergence is higher in countries with a low level of development.

Keywords

Club convergence; energy intensity; former USSR.

1. Introduction*

After the collapse of the USSR former Soviet republics, having become independent countries, embarked on paths of their own. The developmental trajectories of these countries differed greatly. In three of them —Lithuania, Latvia, and Estonia—the economic transformation to a modern market economy was very strong, and now they are members of the European Union. Currently, negotiations are under way for Armenia, Azerbaijan, Georgia, Moldova, and Ukraine to sign the European Union Association Agreement. The economies of Azerbaijan, Kazakhstan, and Russia have grown significantly, mainly thanks to reserves of petroleum, gas, and other natural resources. Tajikistan and Kyrgyzstan, however, are currently among the poorest countries in the world, and are agro-industrial. A large portion of their GDP is from migrant remittances. According to the World Bank, in 2011 migrant remittances composed 47% of the GDP in Tajikistan, and 29% in Kyrgyzstan.

An enormous reserve of natural energy resources lies in the territory of the former Soviet Union. The planned economy of a unified economic space gave each Soviet republic access to these natural riches. Low domestic energy prices that did not vary substantially from country to country made the incentive for effective energy use very low. As a result, the Soviet economy was one of the most energy intensive in the world. After the collapse of the USSR, this single economic space with uniform prices disappeared. Former Soviet countries that were rich with natural resources built their own economies on this wealth. Other countries, in which natural resources were virtually absent, were forced to buy from resource rich countries—mainly Russia—due to geographic factors and established energy infrastructure. For some time after the collapse of the USSR Russia sold energy resources to its former Soviet partners at favorable prices. However, it gradually began to retreat from this practice. Conflicts over gas serve as an example of this: between Russia and Ukraine in 2006 and 2008, Russia and Belarus in 2006 and 2007 as well as in 2010, and the rise in gas prices and curtail of gas delivery in Moldova beginning in 2006.

The high cost of energy as well as political and economic pressure from suppliers has created incentive for more efficient energy consumption. Furthermore economic growth is itself associated with reduced GDP energy intensity. Modernization of the economy has lead to newer and less energy intensive modes of production. Another consideration in the economical use of energy with economic development is environmental protection. The consumption and conversion of energy is one of the most polluting activities. Countries with significant environmental problems are interested in the production of GDP in a less energy intensive way. Rising standards of living increase the demand for environmental quality and, consequently, attention to environmental issues.

In this paper we analyse the convergence of GDP energy intensity in the post-Soviet world to the level of developed countries of the European Union. A convergence of energy intensity may signify that technological differences between regions decrease with time. But an absence of convergence may reveal the particularities in the spread of technology in the field of energy and serve as motivation for supporting energy conservation policy.

We want to answer the following questions:

- Is there a convergence in GDP energy intensity of former Soviet countries with the level of developed countries of the EU, and what is the rate of this convergence?
- Does GDP growth lead to a decrease in GDP energy intensity, and, if so, to what extent?
- Do these processes differ in countries of the former USSR that have transformed into market economies and joined the EU? In countries aspiring to European integration? In countries rich

* The authors are grateful to Exxon Mobil for financial support.

with natural resources that build their wealth on these resources? In countries that currently demonstrate a low level of economic development?

The paper is organized as follows. Section 2 contains brief review of convergence types. In Section 3 related studies are listed. Section 4 provides the source and description of data used in the study. Section 5 includes econometric methodology and empirical results. Subsection 5.1 evaluates club convergence in GDP per capita. Subsection 5.2 is devoted to conditional β -convergences in real per capita income and energy intensity of GDP in each club.

2. Types of convergence

The concept of convergence is commonly associated with the theory of economic growth and reduction in income inequality between countries or regions. However, its application is not limited to economic growth. This is evidenced by the recent increase in the number of studies and articles with relevant ideas and methods in other fields, including energy economics. Three types of convergence are usually considered. β-convergence introduced by (Baumol, 1986) supposes negative relation between initial level of the value of interest (for example, income, carbon dioxide emissions or energy performance, etc.) and the subsequent growth rate. It is due to the fact that lagging counties can take advantage of technologies developed by advanced countries.

Usually one distinguishes between unconditional and conditional β-convergence. The first type implies convergence to a certain steady state which is the same for all countries. The second type suggests that convergence may depend on the specific characteristics of the country, such as the scale of production or energy prices. Classical equation for testing the convergence has the following form

$$\frac{1}{T}\ln\left(\frac{Y_t}{Y_{t-T}}\right) = \alpha + \beta\ln(Y_{t-T}) + other\ \ factors + error, \qquad (1)$$

where Y_t is the value of variable Y in the current time t, Y_{t-T} - its value with lag T. Significant negative coefficient β indicates the presence of convergence. According to Sala-i-Martin (1996a) convergence speed can be calculated as $\lambda = -\frac{1}{T}\ln(1+\beta)$.

Barro and Sala-i-Martin (1990) examined σ- convergence, which is related with decreasing variation of Y over time. Decreasing variance means that the countries are gradually becoming more similar to each other. σ- and β- convergence are connected with each other but not equivalent. Sala-i-Martin (1996b) showed that β- convergence is necessary, but not sufficient for σ-convergence.

The third type of convergence - stochastic convergence - goes back to Quah (1990), who investigated time length of shocks in per capita income. Bernard (1995) and Durlauf (1996) generalized the notion of convergence for time-series.

It is necessary to distinguish between the global and the local (club) convergence. Division by clubs can be made a priori, or be based on the data. Islam (2003) has provided a very detailed review of the literature on convergence which includes different concepts, testing methodology and their correspondence with each other are considered, as well as numerous findings.

3. Related studies

The number of papers on energy intensity convergence is not too large especially in comparison to large body of articles on income and carbon dioxide convergence. Ang (1999) demonstrated that energy intensity varies in wide range and has bigger effect on carbon dioxide emissions than carbon dioxide intensity. Thus energy intensity studies can be useful in exploring the role of industrialized and transition countries in climate change according to their level of development. Later Ang and Liu

(2006) showed that energy intensity has moved from an increasing to a decreasing trend. Cornille and Fankhauser (2004) considered traditionally very energy-intensive economies of Central and Eastern Europe and the former USSR. They came to the conclusion that energy prices and industrial restructuring are the two most important factors for a more efficient use of energy. Markandya and others (2006) studied relation between energy intensity in 12 transition countries of Eastern Europe and 15 countries in the European Union. In particular they prove that a 1% decrease in the per capita income gap between developed and transition economies on average leads to a decrease in the energy intensity growth rate of a transition country.

Mulder and DeGroot (2012) examined 18 OECD countries and 50 sectors during 1970-2005. They found that the sectors of catch-up and developed countries are converging, and their average speed is higher in the service sector than in manufacturing. Wu (2009) confirmed the convergence for China for the period 1995-1999 to 2000-2004, and the divergence for 2000-2004. Le Pen and Sévi (2010a) found that the stochastic convergence is rejected for the group of 97 countries for the period 1971-2003. Le Pen and Sévi (2010b) also tested the presence of deterministic trends in energy intensity for different samples. Liddle (2010) used two large sets of data (111-country sample spanning 1971–2006 and a 134-country sample spanning 1990–2006) to support convergence, which is more increasing in recent years. Zhang (2013) found signs of convergence for the 28 countries of Eastern Europe and Central Asia, using pooled model of panel data.

This paper seeks to extend the analysis of convergence to the energy intensity of GDP in the former Soviet space.

4. Source and description of data

The data source for this study is the database of the World Bank's World development indicators.[1.] We use the following indicators:

- GDP per capita, PPP (constant 2005 international $). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. Data are in constant 2005 international dollars.
- Energy use (kg of oil equivalent) per $1,000 GDP (constant 2005 PPP). Energy use per PPP GDP is the kilogram of oil equivalent of energy use per constant PPP GDP. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. PPP GDP is gross domestic product converted to 2005 constant international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as a U.S. dollar has in the United States.

We analyse 15 countries of the former Soviet Union: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan (hereinafter referred to as FSU countries) in comparison with 13 most energy efficient countries in the European Union in 2010: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Spain, Sweden, United Kingdom (hereinafter referred to as EU13). The data cover the period from 1995 to 2010.

Figure 1 shows the dynamics of energy intensity of GDP. One can see that the energy intensity of GDP in the FSU has decreased during concerned period. This favors convergence hypothesis of energy consumption to the level of the EU. However, the reduction rate and the level achieved to date vary considerably from country to country in the FSU. Figure 2 shows the evolution of GDP per

[1] http://data.worldbank.org/data-catalog/world-development-indicators

capita. Numbers next to the name of the country indicate the ratio of per capita GDP in 2010 to per capita GDP in 2000. Many FSU countries have substantially increased their GDP and reduced the gap between the European Union. It is noticeable that the economic growth in the countries of the FSU had different rates. The variation of GDP per capita in the countries of the former Soviet Union to 2010 has increased. This fact prompted us to highlight the groups of FSU countries that converge to different club equilibria, and analyze processes to reduce energy intensity in these groups of countries separately.

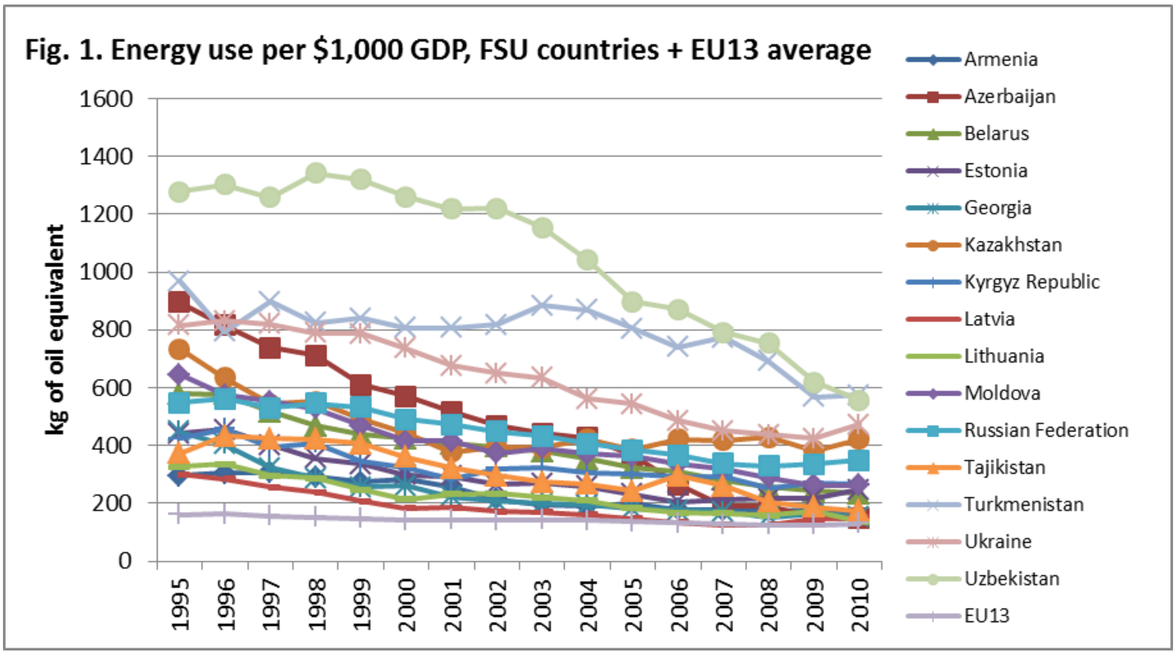


Fig. 1. Energy use per $1,000 GDP, FSU countries + EU13 average

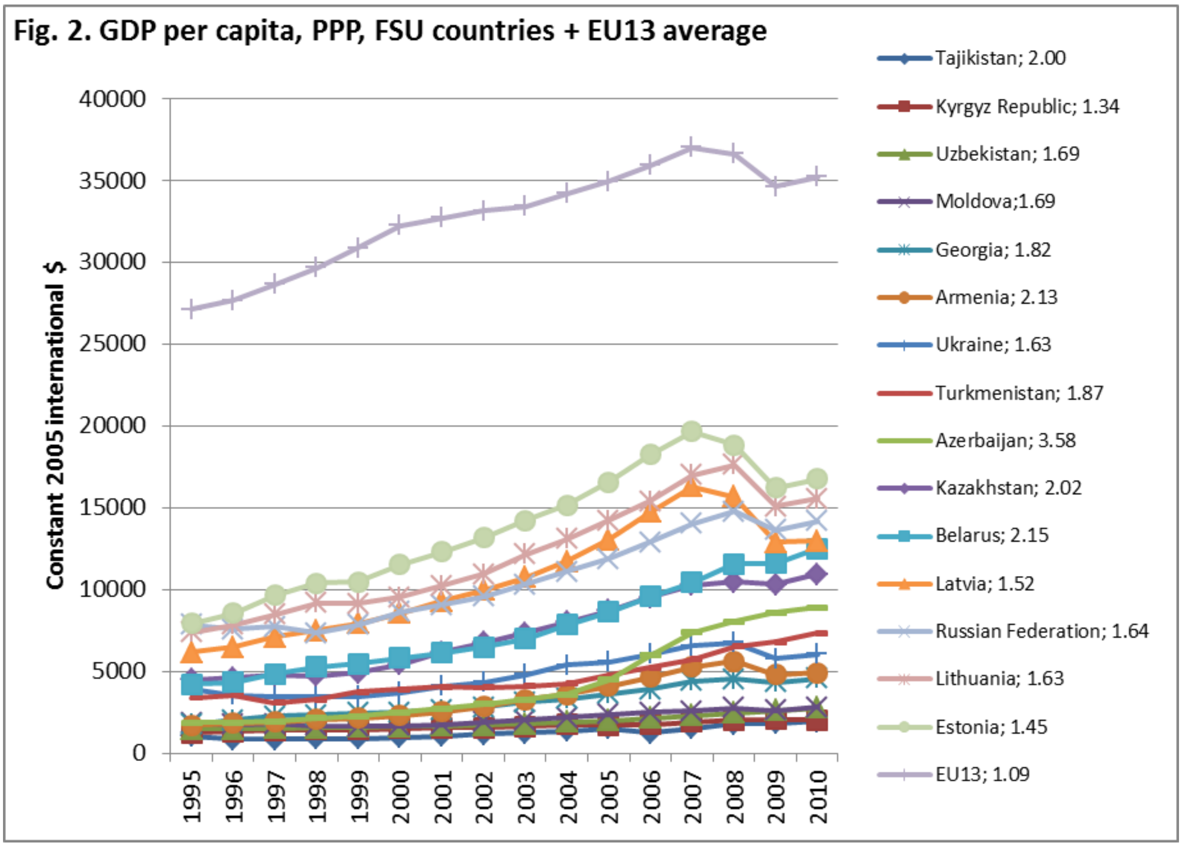
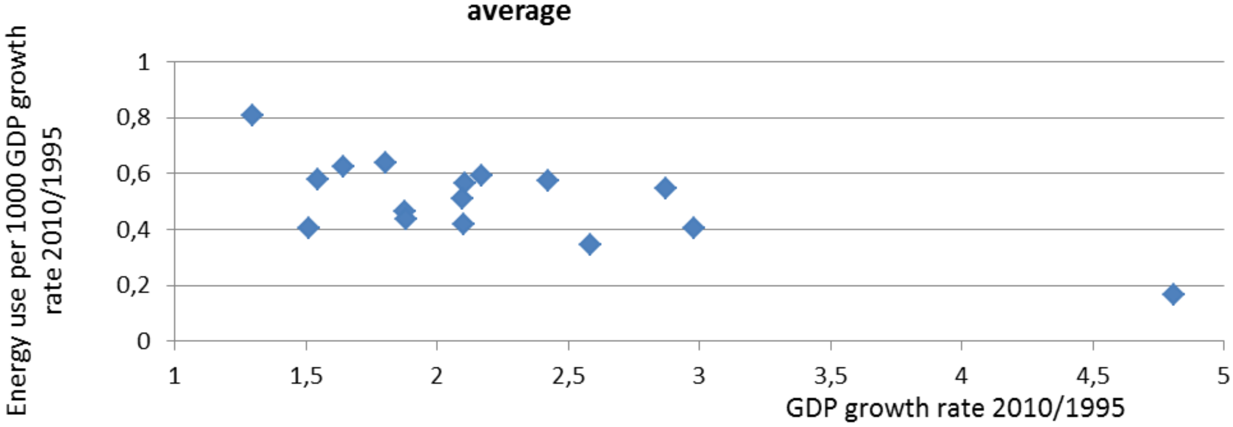


Fig. 2. GDP per capita, PPP, FSU countries + EU13 average

Rate of economic growth and rate of GDP growth are inversely related (Fig. 3), which supports the hypothesis of reducing energy consumption with economic development.

Fig. 3. Energy use growth rate and GDP growth rate FSU countries + EU13 average



5. Methodology and empirical results

We want to verify overall convergence of group countries into homogeneous clubs that exhibit it. Then we further analyse these clubs to investigate factors that affect convergence.

5.1. Club Convergence in GDP per capita

Former Soviet Union countries exhibited different rates of economic growth as already mentioned. The differences in the level of economic development had increased. According to the World Bank classification, today Lithuania, Latvia, Estonia and Russia are high-income economies, while Tajikistan and Kyrgyzstan form a group of low-income economies. We believe that the processes of reducing energy intensity can be different in countries with different levels and rates of economic development. We are going to divide FSU countries into several convergence clubs in GDP per capita.

Our approach is based on the methodology developed by Phillips and Sul (2007). This methodology examines whether the dispersion across cross-sectional units of the variable of interest decreases over time. A regression-based test is proposed and clustering procedure is developed based on this test. This approach does not rely on stationarity assumptions and allows for a wide variety of possible transition paths towards convergence (including subgroup convergence).

Factorial models are standard tool in analyzing panel data sets of different types. The variable of interest X_{it} is decomposed into a common factor μ_t and an unit specific factor loadings $\delta_i, \varepsilon_{it}$ denotes of unit specific idiosyncratic components:

$$X_{it} = \delta_i \mu_t + \varepsilon_{it} \tag{2}$$

Phillips and Sul (2007) offer the following representation of factorial model

$$X_{it} = \delta_{it} \mu_t, \tag{3}$$

where δ_{it} absorbs ε_{it} and the unit-specific component thus representing the idiosyncratic part that varies over time. This approach describes variable of interest by measuring the share δ_{it} of the common growth path μ_t that economy i stands. Time-varying factor loadings δ_{it} models in a semi-parametric form implying non-stationary transitional behaviour as:

$$\delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}, \tag{4}$$

where δ_is fixed, σ_i is an idiosyncratic scale parameter, ξ_{it} is *iid(0, 1)* across *i* and weakly dependent over t, and *L(t)* is a slowly varying function (for example *L(t) = log t*), so that $L(t)\to\infty$ as $t\to\infty$, α denotes the speed of convergence.

The null hypothesis of convergence can be written as:

$$H0\ :\ \delta_i = \delta \text{ and } \alpha \geq 0 \tag{5}$$

and it is tested against the alternative H_A: $\delta_i \neq \delta$ for all i or $\alpha < 0$. Under the null hypothesis of convergence various patterns of transition for units i and j are possible, including temporary divergence, during some periods $\delta_i \neq \delta_j$.

In order to model the transition coefficient δ_{it}, a relative transition parameter h_{it} is constructed as:

$$h_{it} = \frac{X_{it}}{\frac{1}{N}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}}. \tag{6}$$

This parameter measures δ_{it} in relation to the panel average at time *t* and describes the relative departures of economy *i* from the common growth path μ_t.

If panel units converge $(\delta_{it} \to \delta$ for all i as $t \to \infty)$ the relative transition parameters converge to one $(h_{it} \to 1$ for all i as $t \to \infty)$. Then, the cross-sectional variance of h_{it}, denoted by H_t converges to zero:

$$H_t = \frac{1}{N}\sum_{i-1}^{N}(h_{it}-1)^2 \to 0\ \ as\, t \to \infty\,. \tag{7}$$

Phillips and Sul (2007) show that under convergence the H_t has the limiting form

$$H_t \sim \frac{A}{L(t)^2 t^{2\alpha}} \text{ as } t \to \infty \text{ for some } A > 0. \tag{8}$$

Phillips and Sul (2007) test the null hypothesis using the following *log t* regression:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = a + b\log t + u\,, \tag{9}$$

where *L(t) = log(t+1)*. The fitted coefficient of $\log t$ is $\hat{b} = 2\hat{\alpha}$, where $\hat{\alpha}$ is the speed of convergence estimator. A one-sided *t-test* robust to heteroskedasticity and autocorrelation is applied to verify the inequality of the null hypothesis $\alpha \geq 0$. The null hypothesis of convergence is rejected if $t_b <$ −1:65 (at the 5% significance level). Phillips and Sul (2007) recommend to estimate the equation (9) not on a whole sample but on reduced sample, that excludes first rT observations. Based on Monte Carlo simulations, they suggest using r=0.3 for sample sizes below T=50.

Rejection of the null for the panel as a whole does not imply the absence of club convergence. Phillips and Sul (2007) extend their methodology and develop an algorithm for club convergence. They develop a four-step procedure:

Step 1. (Ordering). Cross-sectional units are sorted in descending order on the basis of the last period in the time series dimension of the panel. In the case of significant volatility in X_{it}, ordering can be based on the time series average over the last 1/2 or 1/3 periods.

Step 2. (Core Group Formation). Selecting the first *k* highest units in the panel to form the subgroup G_k for *k=2,…,N*, run the *log t* regression and calculate the convergence test statistic t_k for each subgroup. The core group is the one with the maximum *t*-statistic, given that it is statistically significant, i.e. $t_k > -1.65$. If condition $t_k > -1.65$ does not hold for the first two units in the sample, drop the first unit and continue the procedure from second unit and so on. If no pair of units with $t_k > -1.65$ exists in the entire sample, conclude that there are no convergence clubs in the panel.

Step 3. (Club Membership). One unit at a time is added to the core group and the t-statistic from the *log t* regression is calculated. A new unit classify as member of the club if the *t*-statistic of the associated *log t* regression exceeds some chosen critical value *c*. Based on Monte Carlo simulation, Phillips and Sul (2007) recommend to use $c = 0$, in order to reduce the risk of including a false member into a convergence group. Run the *log t* test for the entire group. If $t_k > -1.65$, this group forms a convergence club. Otherwise, increase the critical value c for the club membership selection, form a new group and check a condition $t_k > -1.65$ for this group. If there are no units except the core group with $t_k > -1.65$, conclude that the convergence club consists only of the core group.

Step 4. (Recursion and Stopping). All units that have not been included in the club identified in the previous steps are tested to check whether they form another club, that is, where $t_k > -1.65$. If not, repeat Steps 1–3 on this group to determine whether the panel includes a smaller subgroup that forms a convergence club. If no core group can be found, then these countries display a divergent behavior.

We apply[2] the methodology described above in order to identify a group of FSU countries that converge to different equilibria. We use GDP per capita, PPP (constant 2005 international $) as indicator of economic development.

For all fifteen countries together the convergence hypothesis is rejected at the 5% significance level because the corresponding t-statistic is -6.86. So we have applied clustering procedure. Three clubs were formed, and besides two countries showed a divergence and were excluded from further analysis. Results are given in table 1.

Table 1. Results of procedure of clubs allocation.

	Club 1	**Club 2**	**Club 2**
Country	Estonia, Latvia, Lithuania, Russia, Belarus, Kazakhstan, Azerbaijan	Ukraine, Armenia, Georgia	Moldova, Uzbekistan, Tajikistan
$\hat{b}$	1.176	0.522	-0.006
t-stat	2.635	1.850	-0.025
Divergent Countries		Turkmenistan, Kyrgyz Republic	

First club comprises the richest countries of the former USSR: Lithuania, Latvia and Estonia, which joined the European Union, energy resources rich Russia, Kazakhstan and Azerbaijan, whose wealth is based largely on the sale of these resources, and Belarus, which development is apparently based on benefits from possession of high level of the human capital. Second club consists of the countries with a medium level of development: Armenia, Georgia and Ukraine. Countries with low levels of development - Moldova, Tajikistan and Uzbekistan – form the third club. Two remaining countries - Turkmenistan and Kyrgyzstan - do not converge to any club equilibrium. In our opinion, this is due to the following reasons. Kyrgyzstan is one of the poorest countries of FSU. It has no hydrocarbon deposits, which became the basis for the growth of many other countries. The country's economy is set up on extensive developing of agriculture and loading old production facilities. As a result, Kyrgyzstan has the lowest economic growth among the FSU countries during the last 10 years (see

2 Evaluation was carried out in Econometric Views 7.0, HAC estimates of standard errors were taken in the form Newey–West.

Fig. 2). On the contrary, Turkmenistan has large reserves of oil and gas. Despite the conservative model of economic development, stipulating the predominance of public sector, Turkmenistan demonstrated a strong economic growth during the past 10 years. The growth rate was high enough to allow Turkmenistan to leave the third club of underdeveloped countries, but not high enough to join the second club.

5.2 Conditional β -convergence in energy intensity

We can improve our finding by analysing rate of convergence and identifying factors that affect it.

Preliminary analysis of the data shows that average EU13 per capita GDP is greater than per capita GDP of the FSU countries, but average energy intensity, conversely, is lower. So the rich countries are more energy efficient, as we initially expected. Based on this we conjecture that GDP growth in FSU will lead to a decrease in energy intensity. In case of transition countries, Markandya et al. (2006) state that income convergence would be a base for energy intensities convergence.

We begin by checking the conditional β-convergence of income, which is a meaningful problem in its own right. We used the classical model with fixed group and time effect

$$\ln\left(\frac{GDP_{i,t}}{GDP_{i,t-1}}\right) = \alpha_i + \mu_t + \beta \ln(GDP_{i,t-1}) + \varepsilon_{it}, \tag{10}$$

where $GDP_{i,t}$ is per capita GDP of country *i* in year *t*. We estimate regression (10) for each club pooled with EU13. The estimation results (see Table 2) indicate that expected negative relationship between the initial level of income and the rate of growth is confirmed. For all three clubs of the coefficients β are significant and negative. Consequently, there is a convergence in income, although very slow one, because small values of β speed $\lambda = -\ln(1+\beta)$ almost equals with the very coefficient β. Note that coefficient β is insignificant for the entire FSU, so the clustering was justified.

Table 2. Regression results, beta-convergence in real per capita GDP, coefficients for time and group effects are omitted

	FSU+13EU	1 club+13EU	2 club+13EU	3 club+13EU
β	-0.017	-0.024***	-0.056***	-0.065**
R^2 *within*	0.44	0.48	0.60	0.30
obs	415	319	256	256

Hereinafter, the symbols ***, ** and * denote statistical significance at 1%, 5% and 10% level.

Now we can clarify the factors affecting the convergence. Following Markandya et al. (2006) we estimate equation

$$\ln\left(\frac{IE_{i,t}}{IE_{i,t-1}}\right) = \alpha_i + \mu_t + \gamma_i \ln\left(\frac{IE\_AV_t}{IE_{i,t-1}}\right) + \delta_i \ln\left(\frac{Y\_AV_t}{Y_{i,t}}\right) + \varepsilon_{it}, \tag{11}$$

where $IE_{i,t}$ - energy intensity of country *i* in year *t*, IE_AV_t - average EU13 energy intensity in year *t*, Y_AV_t - average EU13 GDP per capita in year *t*. We guesstimate positive coefficients. Value γ_i is a rate at which the energy intensity of country *i* will adjust so it will converge average EU13 energy intensity. So 1% decrease in the gap between average EU13 energy intensity and country *i* will reduce intensity growth rate of country *i* by $\gamma_i\%$. If there is convergence in income (as we demonstrated above) then positive δ_i points out that 1% decrease of the gap between EU13 per capita GDP and country *i* pulls down energy intensity growth rate of country *i* by $\delta_i\%$. In both cases we observe convergence in energy intensity. The econometric results are given in table 3.

Table 3. Regression (11) results, by country.

Country	**gamma**	**delta**
Azerbaijan	0.75***	0.9***
Belarus	1.03***	0.95***
Estonia	0.86***	1.02***
Kazakhstan	0.44***	0.18
Latvia	0.77***	0.8***
Lithuania	0.64***	0.82***
Russia	0.48	0.64***
1 club, R-squared=0.72, obs=111		
Armenia	0.26	-0.06
Georgia	0.42***	-0.04
Ukraine	0.93***	0.57***
2 club, R-squared=0.79, obs=48		
Moldova	0.09	0.03
Tajikistan	0.78***	0.85***
Uzbekistan	0.58***	1.3***
3 club, R-squared=0.64, obs=48		

Analysis of the of energy intensity dynamics revealed the following. As expected, most of the coefficients are positive and significant, so most of countries show the convergence to the European average level due to economic development (reduction of the gap between country per capita GDP and the European average level). However, several countries stand out of the general pattern.

The only outsiders in the first club are Kazakhstan and Russia. Energy intensity of Kazakhstan industry is very high – it is 26.95 MJ/$ 2005 in 2010 (for comparison, average FSU is 10.71 MJ/$2005) and is decreasing very slowly, just as the Russian one. Both countries are rich in natural resources, hence incentives to reduce energy intensity of GDP in these countries are not big. Besides both countries are characterized by a high share of industry in GDP (42% and 35 % respectively[3] in

[3] WDI, Industry, value added (% of GDP)

2010). This feature distinguishes them from Azerbaijan, who is also rich in gas and oil, but has the lowest level energy intensity in the FSU (1.37 MJ/$ in 2005) and practically has no heavy machinery.

Now we consider the second club. In general, total final energy consumption has decreased in our sample. And even in those rare cases when it increased the increment rate was no more than 10%. The peculiarity of Armenia and Georgia is that these indicators have increased by 1.6 times and 1. 2 times respectively, which explains the lack of convergence.

There is one outsider in the third club: Moldova. This is an economy with a very high dependence on food production. Migrant remittances to Moldova constitute more than 20% of GDP, which is the highest rate in the FSU and the second in the world.

6. Conclusion

In this paper we analysed the former USSR countries for energy intensity. We figured out 3 clubs in GDP per capita. Two countries (Turkmenistan and Kyrgyzstan) have demonstrated divergence and were excluded for further analysis. We found evidence of β-convergence in income for every club pooled with EU13, wherein the convergence rate is higher for countries with a low level of development.

We investigated the rate of convergence in energy intensity of GDP and identified factors that affect it. The convergence based on its own tendency to the average level EU13 energy intensity exists in almost all FSU countries, with the exception of Russia, Armenia and Moldova. The convergence based on per capita GDP tendency to the average level of EU13 exists in almost all countries, with the exception of Kazakhstan and Georgia.

Empirical results to a certain extent support the hypothesis that energy intensity of GDP in resource-rich countries declines more slowly than in the entire sample. Meanwhile our analysis is of macroeconomics nature.

The decrease of energy intensity can be attributed not only to technological advances, leading to the more efficient use of energy, but also to changes in the structure of the economy and industrial decline. To further investigate the causes of current trends a study of the economic structure and sectoral analysis of energy intensity are needed. We intend to extend current research performing decomposition analysis.

Literature

Ang, B.W. (1999). Is the energy intensity a less useful indicator than the carbon factor in the study of climate change? *Energy Policy,* 27, 943-946

Ang, B.W., Liu, N.(2006). A cross-country analysis of aggregate energy and carbon intensities. *Energy Policy,* 34, 2398-2404

Barro, R.J. and X. Sala-i-Martin. (1990). Economic Growth and Convergence Across the United States. *NBER Working Paper* No. W3419

Cornille, J., Fankhauser, S.(2002). The energy intensity of transition countries. *EBRD Working Paper* No. 72. European Bank for Reconstruction and Development, London

Cornille, J., Fankhauser, S.(2004). The energy intensity of transition countries. *Energy Economics,* 26, 283– 295

Islam, N. (2003). What have we learnt from the convergence debate? *Journal of Economic Surveys*, 17, 309– 362

Le Pen Y., Sévi, B. (2010b) What trends in energy efficiencies? Evidence from a robust test. *Energy Economics,* 32 702–708

Le Pen, Y., Sevi, B. (2009) On the non-convergence of energy intensities: evidence from a pair-wise econometric approach. *Ecological Economics*, 69, 641-650

Liddle, B. (2010) Revisiting world energy intensity convergence for regional differences. *Original Research Article Applied Energy*, Volume 87, Issue 10, October 2010, Pages 3218-3225

Markandya, A., Pedroso-Galinato, S., Streimikiene, D.(2006). Energy intensity in transition economies: Is there convergence towards the EU average? *Energy Economics*, Elsevier, vol. 28(1), pages 121-145

Mulder, P., De Groot, H. L. F. (2012) Structural Change and Convergence of Energy Intensity Across OECD Countries, 1970-2005. *Energy Economics,* Volume 34, Issue 6, November 2012, Pages 1910–1921

Phillips P. C. B., Sul D. Transition modeling and econometric convergence tests // Econometrica. – 2007a.– T. 75. – №. 6. – C. 1771-1855

Wu Yu.M. (2009). Spatial Econometric Analysis of Energy Efficiency Convergence of Chinese Provinces. *Power and Energy Engineering Conference*. APPEEC 2009. Asia-Pacific

Zhang F.(2013). The Energy Transition of the Transition Economies An Empirical Analysis. *Policy Research* Working Paper 6387

Author contacts:

Olga Podkorytova
St. Petersburg State University
Faculty of Economics
Tchaikovsky Street 62
191123 St. Petersburg
Russia

European University of St. Petersburg
Gagarinskaia Street 3
191187 St. Petersburg
Russia
Email: podkorytova@gmail.com

Yulia Raskina
European University of St. Petersburg
Gagarinskaia Street 3
191187 St. Petersburg
Russia
Email: raskina@eu.spb.ru