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On the Existence of Energy Intensity Convergence for Eurasia countries to EU15 and OECD levels: A Panel Data Approach

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Abstract

This study examines the relationship between the energy intensity in 15 Eurasia countries and that in the EU15 and OECD countries. The historical data clearly have some evidence of convergence in levels of intensity. We conclude that a detailed model including lagged adjustments confirms the existence of convergence, however, during the forecasted period, only some countries in the control group will probably able to reduce their energy intensities to EU15 and OECD levels. The study, to some extent, can be seen as the expansion of the model studied by Markandya, Pedroso-Galinato and Streimikiene (2006) to a larger group of countries in a more recent period.

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1. Preamble

World total final energy consumption has doubled since its observed level of 3.7 million toe in early 1990s. While the question how the world energy demand trend will come out in decades to come is crucial, policy makers need to know how their economies develop in terms of the total amount of energy used to produce each unit of output, namely energy intensity. As developing countries account for a considerable volume of world total output, their skills in handling technological improvements to shift to a less energy intensive economy will determine the growth rate of world total final energy demand. Trends in overall energy use relative to GDP indicate the general relationship of energy consumption to economic development and provide a rough basis for projecting energy consumption as well as, although we do not mention here, its environmental impacts with economic growth. The ratio of energy use to GDP indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a wide range of production and consumption activities.

It is expected that the Eurasia countries with lower initial income will have greater growth rates while developed EU countries will have a slower pace. The discrepancy between growth rates implies an income convergence. Moreover, while some economists attempted to explain the changes in energy intensities in terms of the changes in energy prices and some other policies, it is widely accepted that the economic activity is the driving force for a country's level of energy intensity. Thus, it can be anticipated that if a country increases its output, it will (have to be) more energy efficient while decreasing its energy intensity.

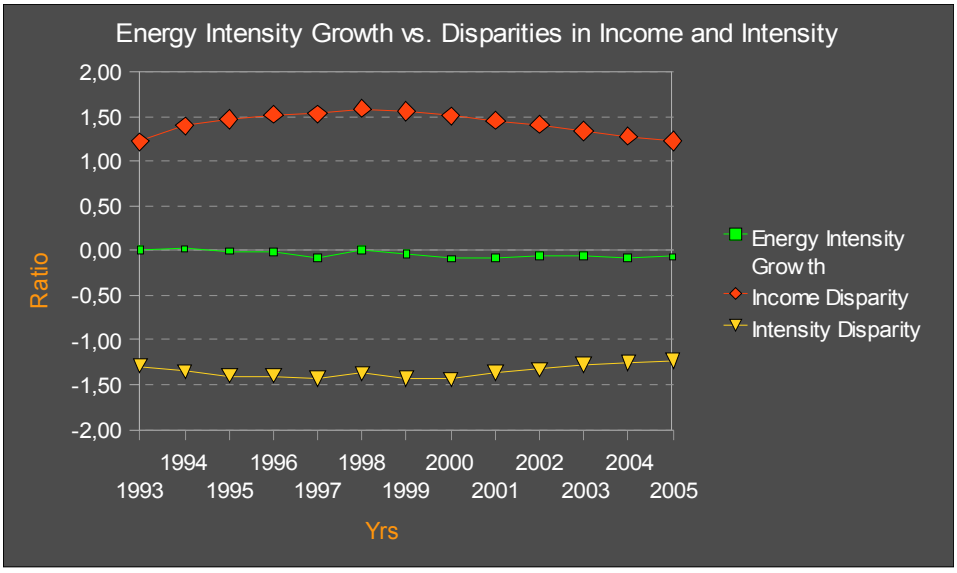


Fig. 1 – Energy intensity growth in Eurasia (1)

Figs. 1 and 2 provide a rough evidence for the mechanism of convergence. Starting from the second half of the last decade, the income gap (downward trending red lines) and energy intensity gap (upward trending yellow lines) between Eurasia countries and other groups, namely EU15 and OECD, has begun to close. More importantly, energy intensity growth rates fell down to negative region simultaneously with the closure of the discrepancies mentioned above.

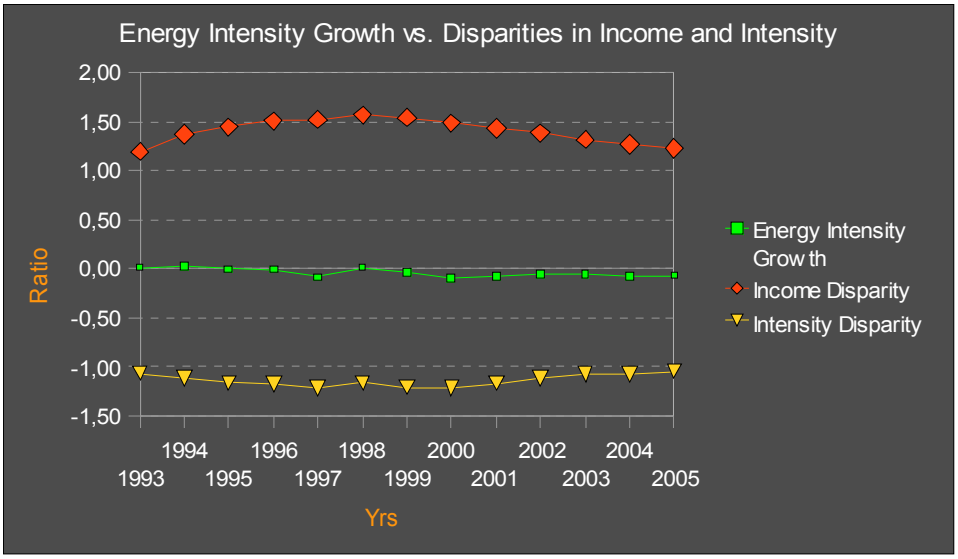


Fig. 2 – Energy intensity growth in Eurasia (2)

In this study, we examine that whether there is an income convergence between developing Eurasia economies, with higher initial energy intensities and lower income, and developed (EU15, OECD) countries, with lower initial energy intensities and higher income, throughout the 1980-2005 period; and if there is; whether it led an energy intensity convergence. Afterwards, these findings will be exploited to estimate future trends in energy intensity and energy demand, which is directly associated with potential energy policies of and environmental effects reflected by the considered countries. However, it must be noted that, countries like USA, Canada, Russia and Norway abnormally have high intensities of energy use due to their some special attributes (i.e. low population density against large land surface, cold climate as well as excessive consumption habits), while these have direct impacts on the length of the future convergence period.

The preliminary data do not suppress the significance of the study. During early 1990s - just after the collapse of the FSU[4] - Eurasia region has significantly mitigated its energy use in either absolute

4 The FSU refers to the Former Soviet Union

and proportional terms, however, the region's output fell more quickly. As a result, energy intensity increased. In the second half of the decade entered the Eurasian countries into an economic recovery. Particularly after the devaluation of the Russian ruble, in the late 1990s, did the Eurasian industrial sectors begin to strengthen. Since then, the economic growth in Eurasia has begun to outpace growth in energy use significantly, and the intensity of energy use started to decline, while converging to reasonable rates. Fig. 1 plots the coefficient of standart deviation of energy intensity for Eurasia and OECD[5] countries since 1992.

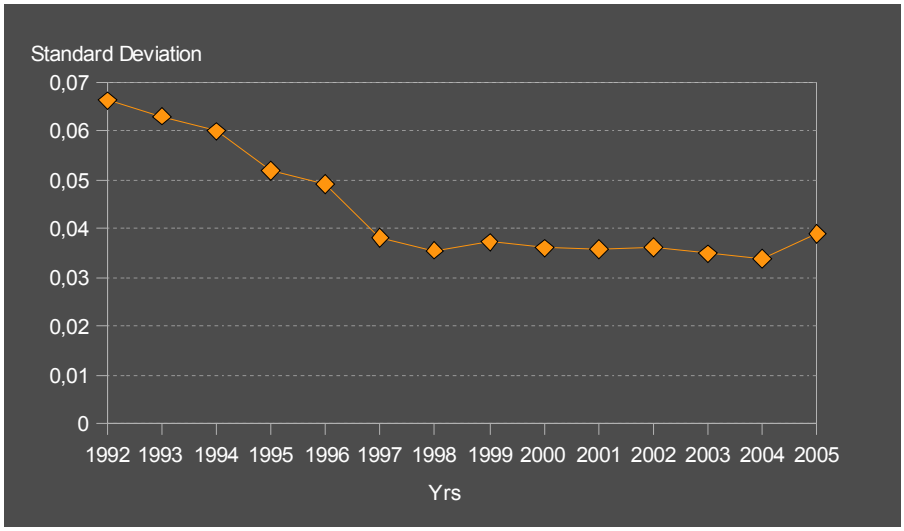


Fig. 3 – Coefficient of standart deviation of energy intensity: Eurasia, EU15, OECD

This study's outline is as follows. Section 2 reviews the previous literature and investigates the related studies scanned. Section 3 introduces the raw data used and specifies the data sources. Section 4 is the place the hypothesis asserted and the model that used to show the estimation of the convergences built. Section 5 explains the methodology and reveals the regression results. Section 6 puts forth the results and its implications. Section 7 relates the policies implemented or not implemented by the transition countries and the adjustment process. Section 8 gives estimation for the energy intensities and consumptions of focus countries. And lastly, the paper is closed by a synopsis and conclusion.

2. Related Studies

The former studies will be mentioned under two subgroups. One group focused on the issue of convergence, particularly convergence of income among a group of countries as well as regions in a

5 The OECD group currently includes all of the EU15 countries of special interest for this study.

country. The others examined the convergence in energy intensity.

Baumol (1986), Dowrick and Nguyen (1989), Mankiw, Romer and Weil (1992), and Barro and Sala-i-Martin (1992), among others, supported the hypothesis of convergence in income level across developed countries.

Barro and Sala-i-Martin (1992), in their leading paper, provided detailed evidence of regional income convergence in 48 contiguous states of USA, seven European countries, and Japan. They estimated a two percent annual rate of convergence in most of the developed countries examined. Although empirical studies for developed countries are widely included in the literature, those for developing countries are quite rare. Koo, Kim and Kim (1998) found that Korea, as a rapidly developing country, has experienced an annual four to six percent convergence of regional incomes. That was higher than what Barro and Sala-i Martin (1992) found.

The literature on the evidence for energy intensity converence is also limited. The early study belongs to Cornille and Fankhauser (2002, 2004) who sought to explain changes in energy intensity of transition economies in terms of the changes in the structure of GDP, energy prices and market regulations. Ang and Liu (2006), in their recent across-country studies, found that well-developed countries, between 1975 and 1997, have been able to achieve significant reductions in the growth of energy consumption for each percentage increase in economic growth. Markandya, Pedroso-Galitano and Streimikiene (2006) investigated the relationship between the energy intensity in 12 transition countries of Eastern Europe and that in the EU15 countries. They concluded that energy intensities of these transition countries will significantly converge towards that of EU15 level between 2000 and 2020.

3. Raw Data and Source Description

In this paper, data collected from International Monetary Fund (IMF, 2008), Energy Information Administration (EIA,) are used for the analysis. The country groups that are analyzed are the EU15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom), Eurasia (Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan) and the OECD. The analysis is run via investigating the income levels (i.e. real GDP per capita) and energy consumption per capita (in terms of Btu). The selections based on the fact that the EU15 and OECD groups have developed members and these countries have low levels of energy intensity while enjoying a high income level. On the contrary,

the Eurasia group members have lower but increasing level of incomes and a higher level of energy intensity.

3.1.Income: Gross Domestic Product per capita (1992-2005)

The gross domestic product (GDP) per capita data for countries have been taken from the IMF's World Economic Outlook April 2008 (IMF, 2008). It's cited in current Purchasing Power Parity (PPP) dollars per capita. Per capita values are used so as to make the values comparable and current PPP dollars are used to make the comparison just and feasible between countries across years.

3.2.Energy Consumption (1992-2005)

The total primary energy consumption (TPC) data are obtained from EIA and its measure unit is quadrillion Btu. The energy intensity figures are found via dividing TPC by GDP. So the unit of measure is 'Btu per 2008 PPP dollar'.
The EU15 and OECD energy intensities are calculated by taking their average and two representative values for these groups are acquired. And, then Eurasia countries' values are compared and analyzed with those of the two representative figures.

4. Hypothesis and Estimation Model

Data on energy intensity clearly shows that Eurasian countries have higher levels of intensity that of EU15 and OECD countries. When the income a poorer country has a greater rate of growth than EU15 and OECD average, it is expected that the transition country will become less energy intensive. We perform a two-step analysis to test this relationship. First, the existence of income convergence[6] inside two subgroups (Eurasia and EU15, Eurasia and OECD) will be examined. Next, the assumption of whether the decline in income gap between Eurasia and other two country groups leads to energy intensity reduction in Eurasia countries will be investigated.

4.1.Income convergence

We use the concept of β-convergence which assumes that low income economies tend to growth faster than the rich countries. It takes into account technology levels, population growth rates,

6 The term "Income Convergence" corresponds to decline in income gap between the considered countries.

institutional differences as well as the differences in initial levels of income (Islam, 2003). The equation for the β-convergence is:

$$\ln\left(\frac{y_{i,t}}{y_{i,t-1}}\right) = a + b\ln(y_{i,t-1}) + 'country, time dummies' + u_{i,t}$$

Eqn. 1 – Estimating income convergence

where $\ln(y_{i,t}/y_{i,t-1})$ refers to per capita income growth at time t for Eurasia country i and $\ln(y_{i,t-1})$ refers to initial income. The value of β where the name of this concept comes from can be defined as the speed of convergence and is equal to $-\ln(1+b)/T$, where T reflects the number of the time intervals.

A negative estimate of b implies the tendency of relatively poor Eurasia countries to be keep up with relatively rich EU15 and OECD countries in terms of per capita income levels (Islam, 2003).

4.2.Energy Intensity Convergence

Below we elaborate on the term energy consumption and its internal part energy intensity. Energy consumption per capita can be broken down into two parts:

$$e_{i,t} = \frac{E_{i,t}}{Y_{i,t}} \cdot \frac{Y_{i,t}}{P_{i,t}}$$

Eqn. 2 – Restating energy consumption per capita

$$e_{i,t} = \varepsilon_{i,t} \cdot y_{i,t}$$

Eqn. 3 – Restating energy consumption per capita

where the first multiplier stands for energy consumption per unit of output and the latter for per capita income. It is obvious that the evolution of $e_{i,t}$ over time in Eurasia economies depends directly on the changes in $\varepsilon_{i,t}$ and $y_{i,t}$.

The estimated growth rate of $\varepsilon_{i,t}$ is determined by two factors: the country i's desired level of energy intensity, which hinges upon the income gap between the country i and that of EU15 or OECD (see Eqn. 4); and the extent to which the country is close to or far away from its desired level of intensity (see Eqn. 5).

$$\varepsilon'_{i,t} = A.\left(\frac{y_{u,t}}{y_{i,t}}\right)^{\eta}.\varepsilon_{u,t}$$

Eqn. 4 – Estimating desired level of energy intensity

$$\varepsilon_{i,t} = \varepsilon_{i,t-1}.\left(\frac{\varepsilon'_{i,t}}{\varepsilon_{i,t-1}}\right)^{\mu}$$

Eqn. 5 – Estimating energy intensity with lagged adjustment

η refers to the rate at which energy intensity gap adjusts for every percent change in the income gap between the EU or OECD and a Eurasia country. The other parameter, μ, refers to the rate at which the actual energy intensity growth rate adjusts to converge with the desired growth. We substitute Eqn. 4 to Eqn. 5 and derive,

$$\ln(\varepsilon_{i,t}) - \ln(\varepsilon_{i,t-1}) = \mu.ln(A) + \mu.(\ln(\varepsilon_{u,t}) - \ln(\varepsilon_{i,t-1})) + \mu.\eta.ln((y_{u,t}) - \ln(y_{i,t}))$$

Eqn. 6 – Estimating energy intensity growth (Eqn. 4 + Eqn. 5)

If we use B, C and D to substitute for the coefficients of Eqn.6, we have a more simplified form:

$$\ln\left(\frac{\varepsilon_{i,t}}{\varepsilon_{i,t-1}}\right) = B + C.ln\left(\frac{\varepsilon_{u,t}}{\varepsilon_{i,t-1}}\right) + D.ln\left(\frac{y_{u,t}}{y_{i,t}}\right) + 'country\,dummies' + u_{i,t}$$

Eqn. 7 – Estimating energy intensity growth (Restatement of Eqn. 6)

where $\hat{B} = \hat{\mu}.\ln(\hat{A})$ $\hat{C} = \hat{\mu}$ and $\hat{D} = \hat{\mu}.\hat{\eta}$ We will run the regression on Eqn. 6 and convert these coefficients back to derive key parameters in Eqns. 4 and 5. The equation includes only country, since we cannot detect time-specific fixed intercept and slope effects.

A positive estimate for C implies that the energy intensity of a Eurasia country will decline so it will converge to average EU15-OECD level as long as there exists a gap between the energy intensities of the two. The rate at which country i is able to decrease its intensity will be positively correlated with the size of the intensity gap. A positive estimate for D, on the contrary, implies that the energy intensity of a Eurasia country will increase as long as there exists a gap between the income levels of the two. The rate at which country i is able to increase its intensity will be positively correlated with the size of the income gap.

Regression results, β-convergence in real per capita GDP
Eurasia and EU15 countries

Variable	Coefficient	S.E.	t-Statistic	Prob.	Sign.
Intercept	1,39	0,18	7,74	0,00	*
Initial Income	-0,18	0,02	-7,53	0,00	*
Country Dummies					
Time Dummies					
Number of Observations					390
R-square (Adj.)					0,60
R-square					0,46

Country Dummies Base: Uzbekistan
Time Dummies Base: 2005
*, ** and *** denote statistical significances at 1%, 10% and 10%+ level, respectively.

Table 1 – Income convergence: within Eurasia + EU15 group

5. Methodology

The selection process of estimation method to employ generally follows a two-step way: testing whether the data allow pooling and determining the type of estimator, namely fixed or random effects estimator. These steps can be performed by a pair of particular F tests for each of three model estimated. At the first stage, the F statistic we calculated was great enough to reject the null hypothesis of homogeneity across each country, which indicates that OLS is not applicable but panel data estimation via fixed or random effects is appropriate. At the next stage, we applied another F test to examine whether the fixed effects model fits with the data. The F-statistic implied the existence of fixed cross-country effects. Unsurprisingly, other studies focusing on the convergence issues mostly employed panel data approach in estimating β-convergence, either conditional or unconditional. The panel data approach has generally been exploited to investigate convergence across countries that are selected from specific country groups.

Regression results, β-convergence in real per capita GDP
Eurasia and OECD countries

Variable	Coefficient	S.E.	t-Statistic	Prob.	Sign.
Intercept	1,46	0,15	9,77	0,00	*
Initial Income	-0,19	0,02	-9,55	0,00	*
Country Dummies					
Time Dummies					
Number of Observations					585
R-square (Adj.)					0,59
R-square					0,38

Country Dummies Base: Uzbekistan
Time Dummies Base: 2005
*, ** and *** denote statistical significances at 1%, 10% and 10%+ level, respectively.

Table 2 – Income convergence: within Eurasia + OECD group

6. Outcome and its Implications

Table 1 and 2 show the regression results for income convergence (Eqn. 1). The estimated b value is negative for either groups, namely Eurasia-EU15 and Eurasia-OECD, therefore the existence of income convergence is supported. Overall, the effect on income growth of a 1% increase (decrease) is estimated to be a 0.18% and 0.19% decrease, respectively for Eurasia-EU15 and Eurasia-OECD groups. Results are statistically robust.

Regression results, convergence in energy intensity
Eurasia and EU15 countries

Country	Intercept		Slope coefficients			
	B+θ*i*	Sign.	C+ρ*i*	Sign.	D+σ*i*	Sign.
Armenia	0,03	*	0,52	**		
Azerbaijan	-0,32	*	0,11	*		
Belarus	-0,12	*	0,23	*		
Estonia	0,40	**	0,58	**		
Georgia	-0,98	*	0,33	*		
Kazakhstan	0,66	**	0,28	*		
Kyrgyzstan	0,03	*	0,38	*		
Latvia	-0,22	*	0,34	*	0,18	*
Lithuania	-0,20	*	0,11	*		
Moldova	0,27	**	0,77	**		
Russia	0,25	**	0,40	**		
Tajikistan	0,39	**	0,58	**		
Turkmenistan	-0,09	*	0,21	*		
Ukraine	0,37	**	0,55	**		
Uzbekistan	1,97	*	1,30	*		
Average Eurasia	0,03		0,38		0,18	
Number of Observations						585
R-square (Adj.)						0,59
R-square						0,38

Country Dummies Base: Uzbekistan
Time Dummies Base: 1992
*, ** and *** denote statistical significances at 1%, 10% and 10%+ level, respectively.

Table 3 – Energy intensity convergence: within Eurasia + EU15 + OECD group (θ, ρ and σ denote the country dummy variables for intercept and slope coefficients.)

With regard to examining the energy intensity growth rates of Eurasia countries, the regression results obtained from Eqn. 7 are listed in Table 3. It is worth noting that the data did not allow us to estimate country-specific significant slope coefficients for the income gap between Eurasia and the EU15-OECD average. This also prevents us from reaching efficiently estimated individual η values. Markandya et al. (2006) was able to find different values for η in their sample including Central and

Eastern Europe (CEE) countries, however, they were not able to provide an explanation for these differences. As seen in the table, the estimates for coefficient C are statistically significant for all countries mostly at 1% level. The common estimate for coefficient D is also significant at 1% level. Therefore, we can interpret the estimate for C to say that, on average, a decrease by 1% in the ratio $(\varepsilon_{u,t}/\varepsilon_{i,t-1})$ leads to a reduction in the energy intensity growth rate of 0.38%.

Estimates of adjusment parameters From fastest to slowest	
	μ
Uzbekistan	1,30
Moldova	0,77
Estonia	0,58
Tajikistan	0,58
Ukraine	0,55
Armenia	0,52
Russia	0,40
Kyrgyzstan	0,38
Latvia	0,34
Georgia	0,33
Kazakhstan	0,28
Belarus	0,23
Turkmenistan	0,21
Lithuania	0,11
Azerbaijan	0,11

Table 4 – Adjustment speed of energy intensity growth rate to converge with its desired level

Recall that, using Eqn. 1, we found a significant evidence for the real per capita income convergence in the group of focus countries. This result indicates that relatively poor Eurasia countries grew faster than relatively wealthier EU15 and OECD countries while, at the same time, they decreased the income gap arising from this inequality. Related to estimate for D, it can therefore be said that, on average, a 1% decrease in per capita income gap between the Eurasia countries and the EU15-OECD average leads to a decrease in the energy intensity growth rate of a Eurasia country by 0.18%.

Note that we are not allowed by data to estimate country-specific effects for η; however, we obtain a variety of μ values which are statistically significant and vary among Eurasia countries. From Table 3, we can calculate the parameter estimates for each country and the average of these estimates for the entire sample. Table 4 shows the countries with their corresponding μ estimates.

All estimates are significant at least at 10% level. An intuition for interpreting these values was provided by Greene (2000). Thus, in the case of Moldova, 50% of the adjustment to keep up with the desired level of energy intensity occurs in $\ln(0.50)/\ln(1-0.40)=0.47$ of 1 year. The estimated values of the parameter μ may well be influenced by policies and reforms adopted by countries in focus. In the next section, we look at some possible explanatory factors for the difference in the estimated values of μ.

Average annual growth rates of focus countries

	GDP	Population	Energy Demand		GDP	Population	Energy Demand
Country	2006 to 2020	2006 to 2020	2006 to 2020	Country	2006 to 2020	2006 to 2020	2006 to 2020
Eurasia	7,23%	-0,11%	--	Lithuania	7,29%	-0,12%	--
Armenia	7,33%	1,13%	--	Moldova	7,72%	0,00%	--
Azerbaijan	8,16%	0,70%	--	Russia	7,86%	-0,42%	--
Belarus	7,65%	-0,28%	--	Tajikistan	7,13%	0,53%	--
Estonia	6,25%	-0,15%	--	Turkmenistan	8,74%	1,40%	--
Georgia	9,55%	-0,55%	--	Ukraine	7,15%	-0,65%	--
Kazakhstan	8,24%	0,09%	--	Uzbekistan	7,02%	1,18%	--
Kyrgyzstan	6,11%	0,99%	--	OECD	3,72%	0,57%	0,70%
Latvia	4,75%	-0,33%	--	EU15	3,48%	0,44%	0,70%

Table 5 – Adjustment speed of energy intensity growth rate to converge with its desired level

7. Energy intensity reductions and key economic reforms

This paper investigates the relationship between some developing countries in Eurasia and the developed country group of EU15 and the relatively developed OECD group in terms of income and energy intensity convergence. Both of these terms are strongly dependent on the policies implemented to them by the country. Also, if the term *transition* considered, it quickly reveals the process of legislative and juridical reforms as well as catching up some levels of economic and social progress. The analysis of this process and the progress are beyond the scope of this paper, nevertheless, it is very crucial to notice and note that parameters linked to the income and energy intensity convergences may be strongly affected by the policies implemented through the process of transition.

The estimates for the μ[7] and η[8] can be correlated with some other factors such as changes in energy prices and market reforms behalf of transition. EBRD has been evaluating the transition process of

7 The rate at which the actual energy intensity growth rate adjusts to converge with the desired growth rate

8 The rate at which the gap in energy intensity adjusts for every change in income gap between the average EU country and Eurasia country

developing countries in Central Eastern Europe and the Baltic states (CEB), South-Eastern Europe (SEE) and the Commonwealth of Independent States (CIS) by assessing their steps in transition. These steps mainly include market reforms that are achieved.

The market reforms refers to the main conditional changes leading to a competitive, liberalized and efficient market environment, especially encompasses small and large scale privatization, price liberalization, governance and enterprise restructuring, competition policy and electric power reform.

Privatization is the percentage of private ownership with effective corporate governance. Price Liberalization refers to the enhancement of pricing such that the prices reflect the true economic costs and leads to efficient usage of energy. Governance and enterprise indicates improvement of corporate governance. Some examples are significant new investments at the enterprise level, enforcement of bankruptcy legislation, strict credit and subsidy policies for privatization those leads to effective corporate control exercised through domestic financial institutions and markets, fostering market-driven restructuring. Competition policy points out liberating entries into market, establishing or improving competition legislation and institutions, for example reducing the abuse of market power and to promote a competitive environment including the disintegration of dominant conglomerates. Electric power reform denotes the diminishment of government interference in running industry, success of institutional and tariff reform, private sector involvement and restructuring, especially separation of the phases into generation, transmission and distribution, of the industry (EBRD, 1994-2001).

Correlation between μ and η and indicators of economic reform

	L-S privatization	S-S privatization	Governance and enterprise restructuring	Competition policy	Price liberalization	Electric power reform
μ*	0.55	0.27	0.38	0.16	0.49	0.46
η**	-0.62	-0.32	-0.30	-0.14	-0.32	-0.40

* rate of converge to desired energy intensity growth

** rate of adjustment in energy intensity gap given a change in income gap

Table 6 – The correlation between policy variables and μ and η

Table 6 shows the correlation between the EBRD policy indicators and the parameter estimates for μ and η for the period of 1994-2001. As forecasted, the parameters show a strong correlation with

the four policy variables. This is important because effectively implemented market-oriented reform policies lead to a more efficient, structurally developed, competitive corporate environment, and so lesser energy intensity for higher income levels. In the table, most of the policy variables exhibit a strong correlation with μ and η. It's not surprising since a liberalized, privatized and restructured market would work more efficiently and helps to reach desired energy intensity levels quickly with smaller steps of income growth. Electric power reform shows a correlation of 0.46 and -0.40 with μ and η respectively. Also, price liberalization has a strong correlation, 0.49 with μ and -0.32 with η. These are strong indicators that reform policies trigger the convergence of energy intensity with advanced levels. However, the highest value for correlation comes from large scale privatization, 0.55 and -0.62. It's clear that, since the energy companies are relatively big rather than those in other markets, large scale privatization help the market to work more efficiently. From these values, it can be inferred that economic reforms helps countries to reduce energy intensities while also help them in increasing their income.

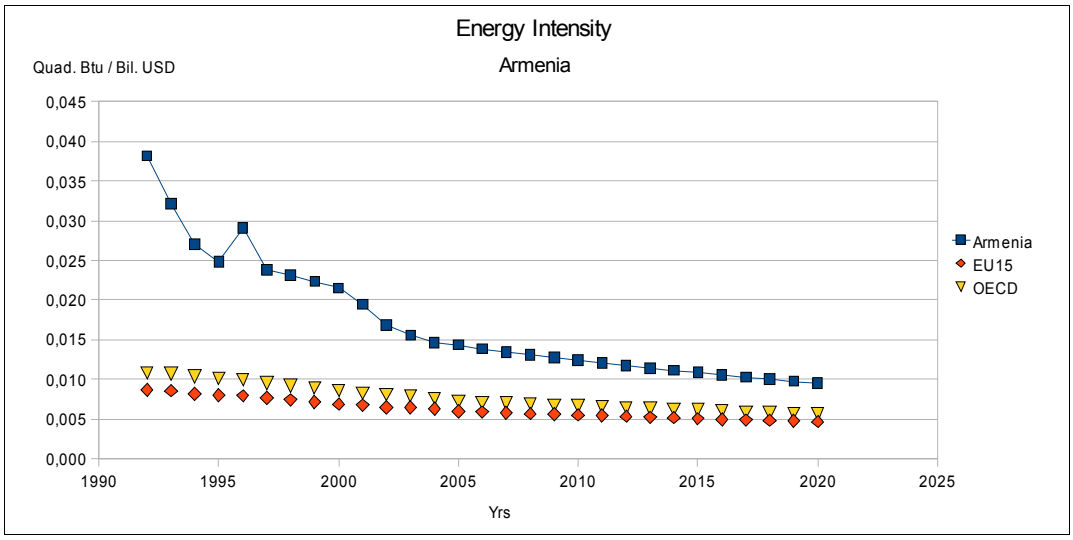


Fig. 3 – Forecast for Armenia's energy intensity

Eurasia countries, except Belarus, Tajikistan, Turkmenistan, have established regulatory authorities and competition agencies in 1990s. Below, Eurasia countries are inspected in terms of their progress in energy sector reforms, some evidences reveal what is found above (EBRD, 2001):

Armenia - Large privatizations, new tax, competition, energy and privatization laws adopted, increase in energy tariffs,

Azerbaijan - New electricity and competition laws adopted. Little small-scale privatization

achieved, competition is newly introduced, negotiations for private power plants are continuing.

Belarus - Competition law adopted.

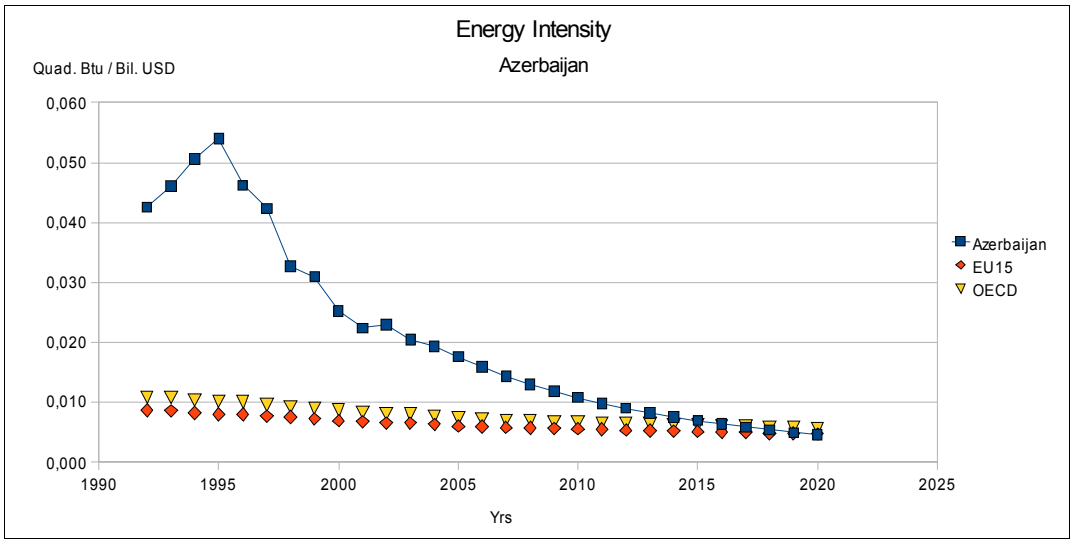


Fig. 4 – Forecast for Azerbaijan's energy intensity

Estonia - EU accession, tax reform, electric power pricing reform, approval of energy law, major adjustments in energy prices.

Georgia - Large scale privatization achieved, new electricity and competition laws enacted,

Kazakhstan - New tax code enacted, new energy law introduced.

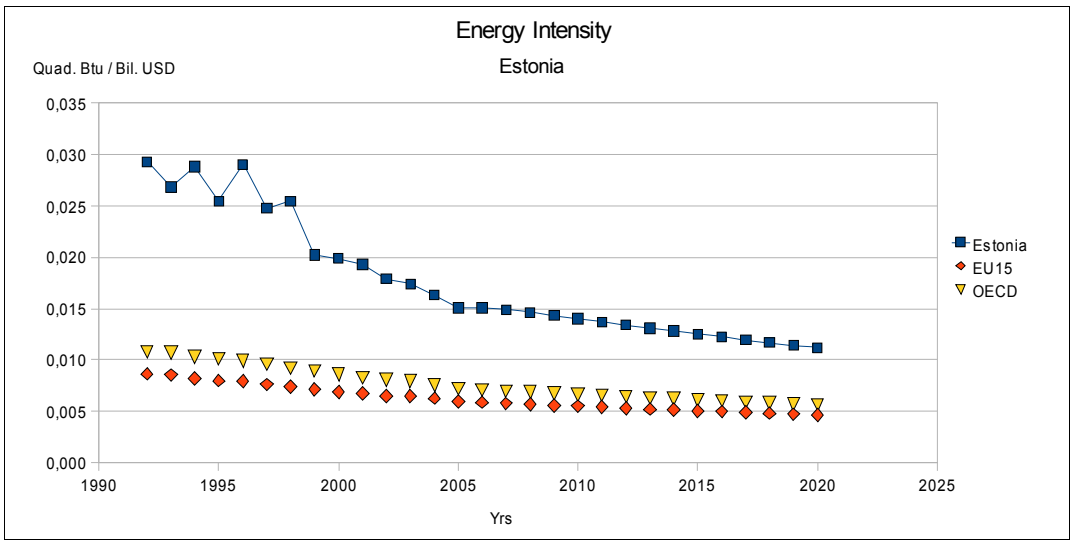


Fig. 5 – Forecast for Estonia's energy intensity

Kyrgyz Republic - New tax, competition and energy laws enacted,

Latvia - EU accession, adjustment of energy tariffs, new energy law and competition law adopted

Lithuania - EU accession, unbundling of energy company, new gas, electricity and competition laws adopted.

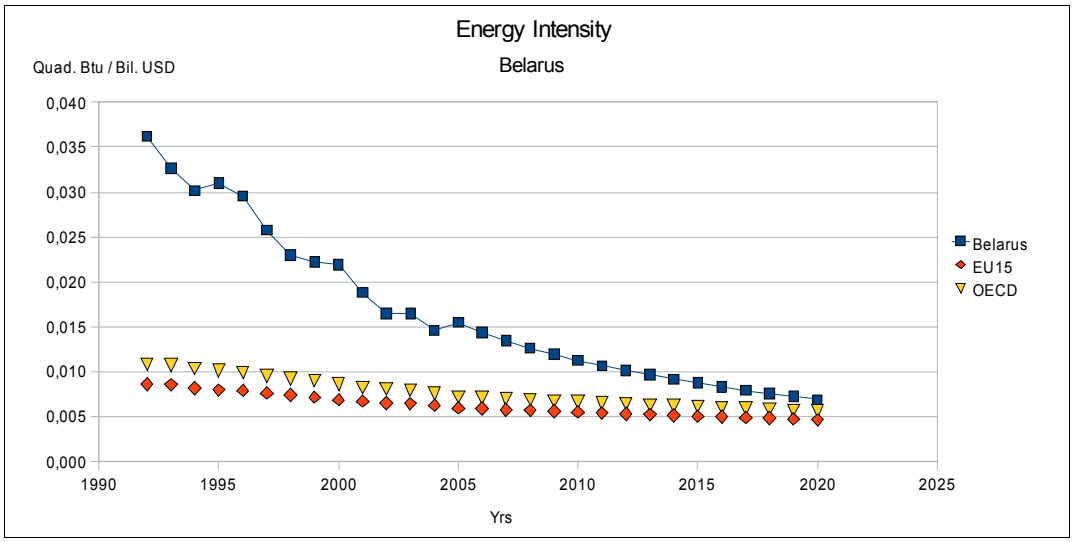


Fig. 6 – Forecast for Belarus' energy intensity

Moldova - Fully liberalized petroleum derivatives private market, semi-privatized distribution sector and the privatization is continuing as well as liberalization of domestic prices by raising energy tariffs to cost-recovery levels, new privatization law adopted.

Russia - New tax code enacted, some energy tariffs conducted.

Tajikistan - Energy sector restricted, anti-monopoly law enacted, energy tariffs reduced.

Turkmenistan - A different case in this group since the government took back some of the reforms achieved.

Ukraine - Large scale privatizations, utility tariffs increased, competition agency established

Uzbekistan - New tax code enacted, competition law passed

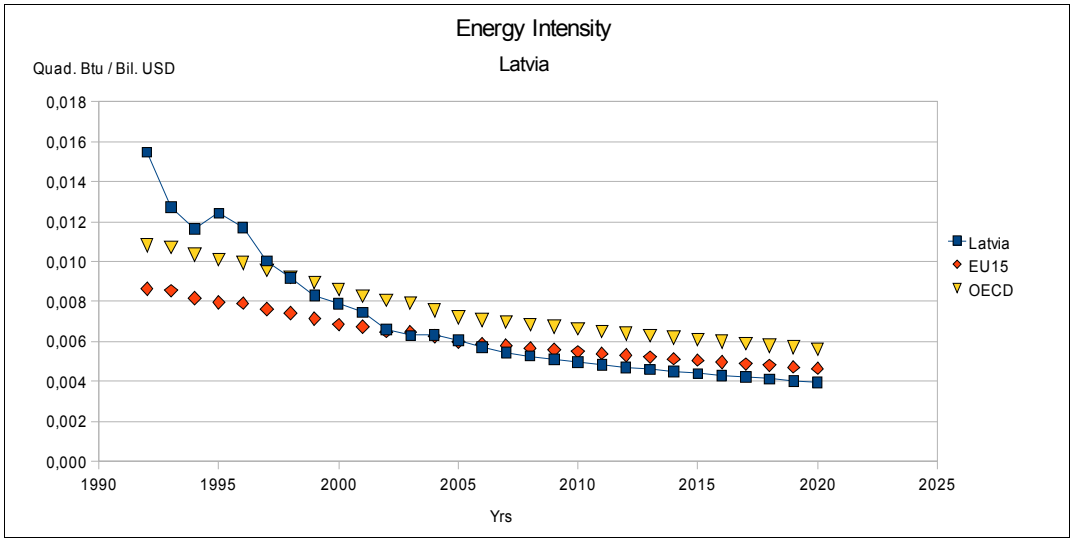


Fig. 7 – Forecast for Latvia's energy intensity

It's noteworthy that some of these countries have undergone little reforms and even took back some of the regulations like Turkmenistan did. Also, some of the countries have acceded to EU, so it is reasonable to regard their market environment below a considerable level in terms of reforms.

As a reminder, it's important to remember that the hydrocarbon exporter countries are raised their income levels enormously due to the shocking increases in hydrocarbon prices. So, it's natural for them to increase their income levels while their energy consumption stays nearly constant. This situation especially applies for countries like Azerbaijan, Turkmenistan and Kazakhstan. These countries increased their incomes due to the energy prices and so their energy intensities are lower than the situation that if the energy prices remained constant.

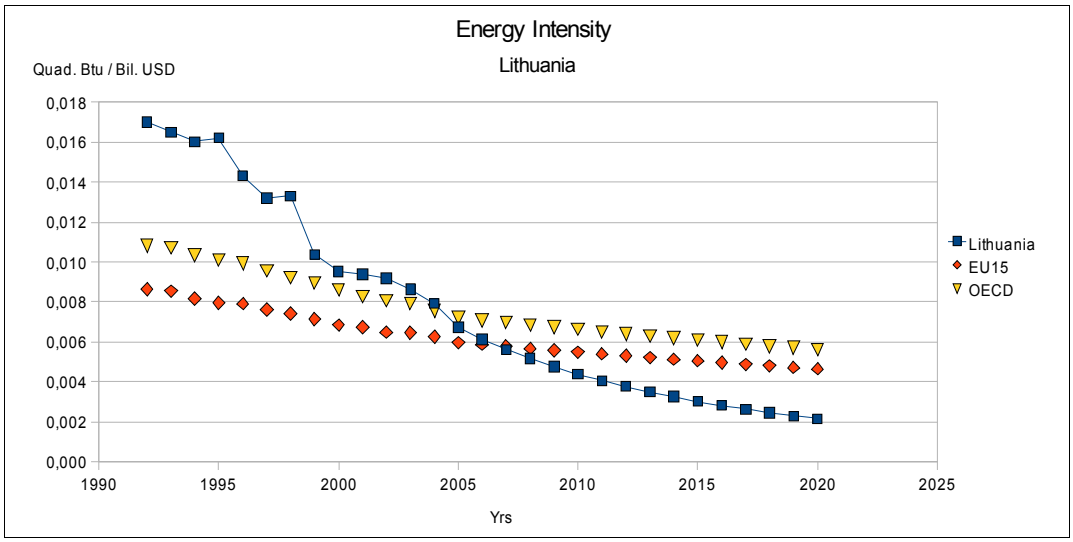


Fig. 8 – Forecast for Lithuania's energy intensity

8. Energy intensities and energy demand in Eurasia countries: 2006-2020

In order to calculate the energy intensity forecasts through the year 2020, we use Eqn. 7 and the coefficients estimated. We need a variety of assumptions concerning the income and population growth rate of the Eurasia countries, as well as the growth rates of EU and OECD energy consumption as provided in Table 5. Unlike the method followed by Markandya et al. (2006), country-specific estimations of μ are employed instead of their average.

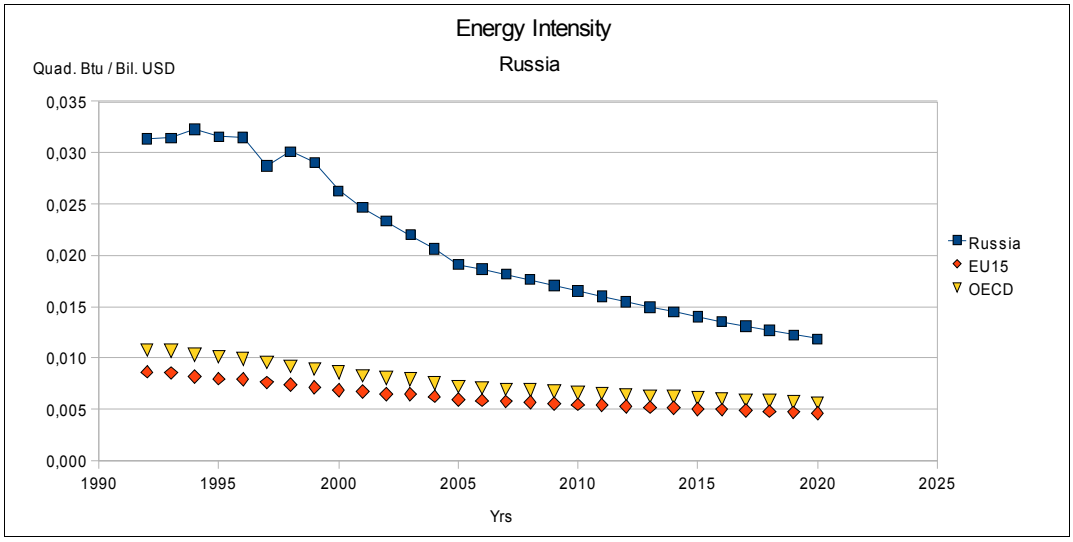


Fig. 9 – Forecast for Russia's energy intensity

Figs. 3- 10[9] and 11-17 (Appendices) show the actual and forecasted (beginning with the year 2006) energy intensity levels of a particular transition country against that of EU15 and OECD. The energy intensities of the EU15 and OECD are both trending downwards through the forecasted period, by an average annual rate of 2% from 2006 to 2020. There appears that energy intensity levels for Azerbaijan, Latvia and Lithuania will significantly converge to the EU15 and OECD levels, meaning that these countries will be more energy efficient in primary consumption terms prior to the end of 2006-2020 period. In addition, Armenia, Belarus and Turkmenistan will probably be completed their convergence process slightly after 2020. Recall that if the convergence speeds cannot outpace the per capita income growth, the reduction in energy intensities do not necessarily result in a decrease in per capita energy demand. Fig. 18 plots the annual per capita energy demand growth for Eurasia countries estimated by Eqn. 7 versus their anticipated per capita GDP growth rates throughout the period 2006-2020.

The overall trend for primary energy consumption for each country within the 15-year period (2006-2020) is increasing. It is noteworthy to give emphasis on that per capita energy demand of Lithuania and Azerbaijan will drop, while countries like Lithuania, Azerbaijan, Kazakhstan and Turkmenistan will have a lower growth in per capita energy demand than that of the EU15 and OECD countries in spite of their higher per capita income growth rates. Similar interpretations can be made for the other countries.

9 For figs. 11-17 please see Appendices.

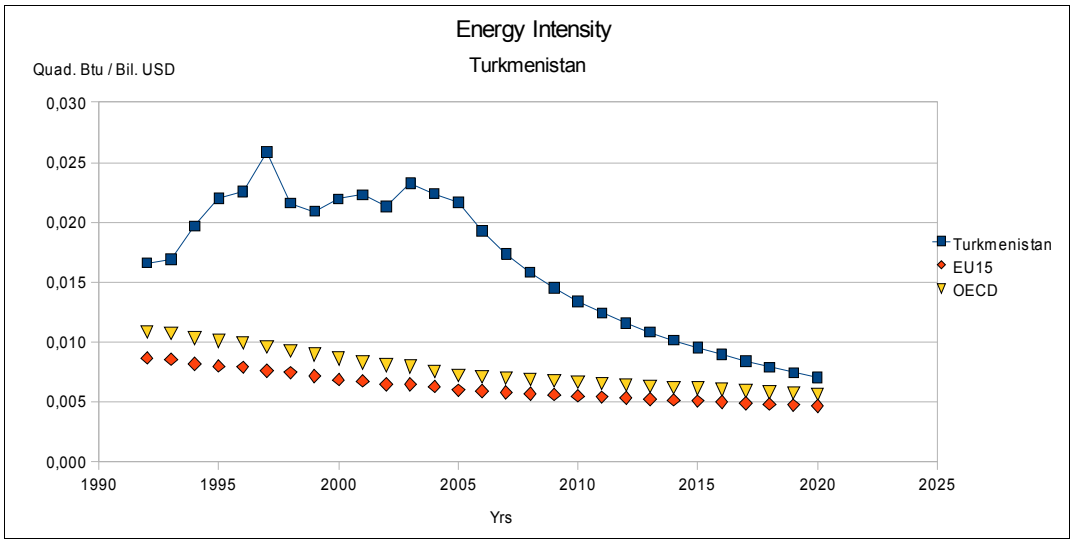


Fig. 10 – Forecast for Turkmenistan's energy intensity

9. Conclusion

This study has examined a developing and transiting country group, Eurasia, in terms of energy and income convergences with the levels of two developed group of countries, EU15 and OECD. It begins with the notification of the evidence that of GDP per capita convergence between transiting Eurasia and, OECD and EU15.

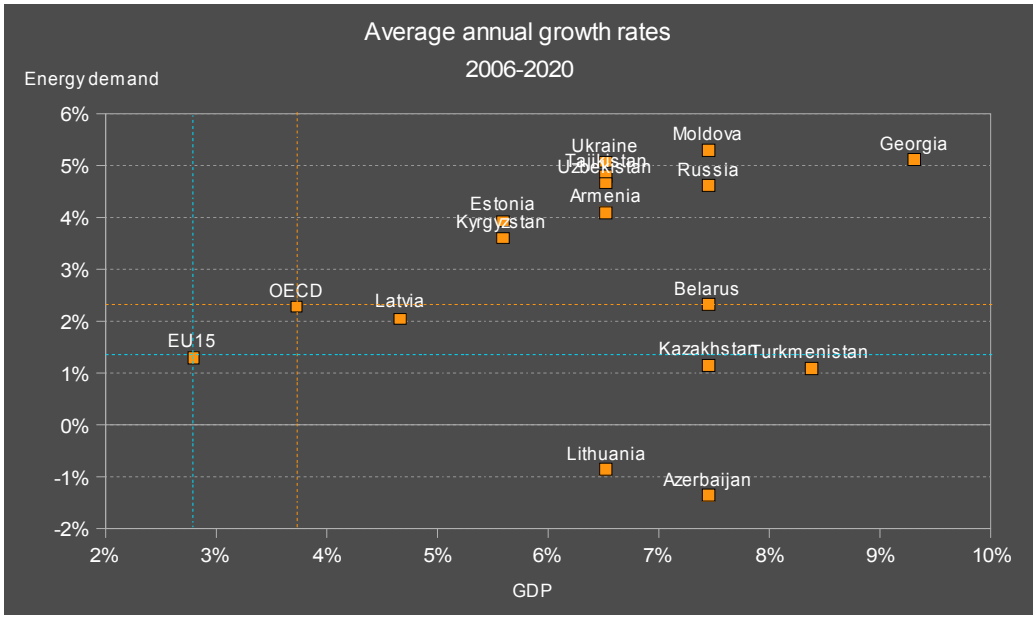


Fig. 18 – Forecasts of energy intensity and income growth

The data revealed that the coefficient for income convergence is -0.18 within Eurasia-EU15 group and -0.19 within Eurasia-OECD, for the period 1992-2005. This result is important to understand how the transition countries will catch up with the developed ones and gives hints about the period of the transition.

After looking for the income convergence, it's expected that the transition countries could lower the energy intensities and may converge with the EU and OECD levels. Again, a rough estimation would indicate convergence and a carefully constructed econometric model of lagged adjustment justified this finding. The parameter μ, which is the rate at the actual energy intensity growth rate adjusts to converge with the desired growth rate, is found as 0.45 on average.

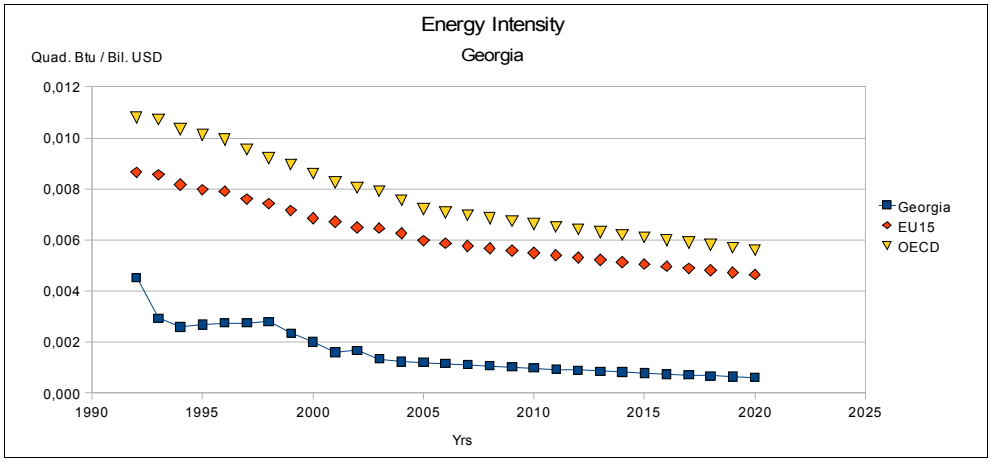
And, another adjustment parameter, η, which is the rate at which the gap in energy intensity adjusts for every change in income gap between the average EU15-OECD and Eurasia country, is calculated as 0.18.

After the quantitative analysis, the paper inspected the relationships between the country level estimates of μ and η with the related market reforms undertaken by the transition countries. It's shown that high correlations do exist between them.

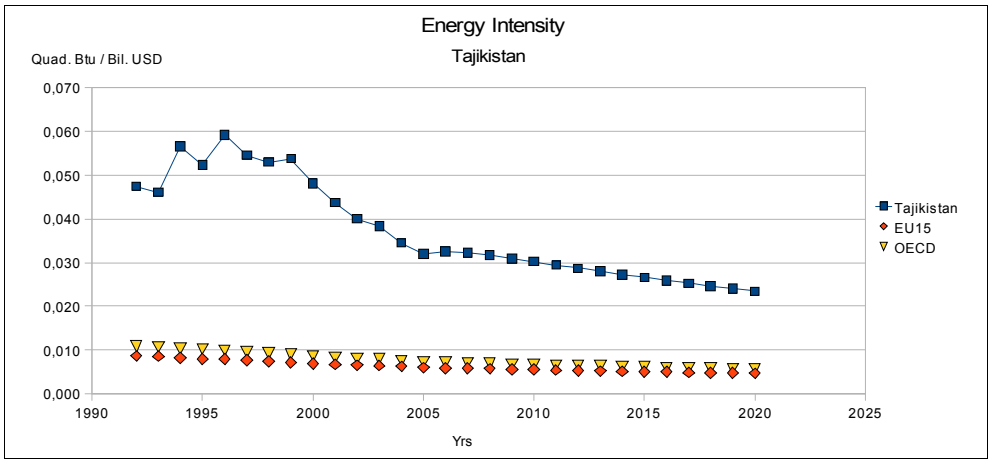
Lastly, the energy intensities and total energy demand for the estimated values of GDP growth for the period of 2006-2020 are estimated. From this point of view, Azerbaijan, Lithuania, Turkmenistan, Armenia, Belarus and Latvia are expected to significantly converge with EU15 and OECD levels in terms of energy intensity. However, it is important to keep in mind that this paper does not put forth a quantitative analysis for the energy prices which is a determinant for energy intensity, especially for the hydrocarbon exporter countries. One of the most robust results of this study is on the future energy demands for Eurasia countries. The data revealed that the policy makers in Lithuania and Azerbaijan should aim to hold energy consumption at or below present levels while allowing economic output to increase. Furthermore, Latvia, Kazakhstan and Turkmenistan will probably observe a lower growth rate in their energy consumption while having greater rates of growth than their EU15 and OECD counterparts. For further analysis, it can be inspected how the energy prices influence the energy intensity changes. Also, an analysis of why some countries converge with higher rates while some do not can be of future interest.

Appendices

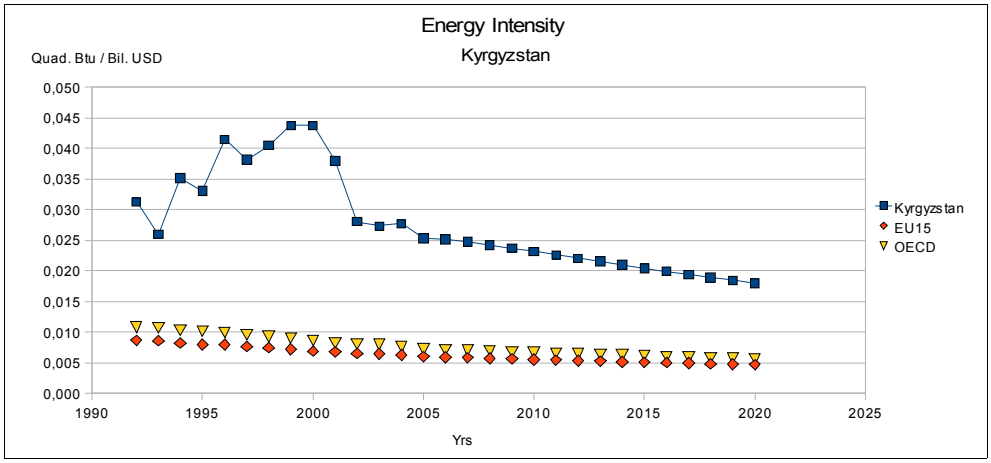
Annex: Fig. 11 – Forecast for Georgia's energy intensity



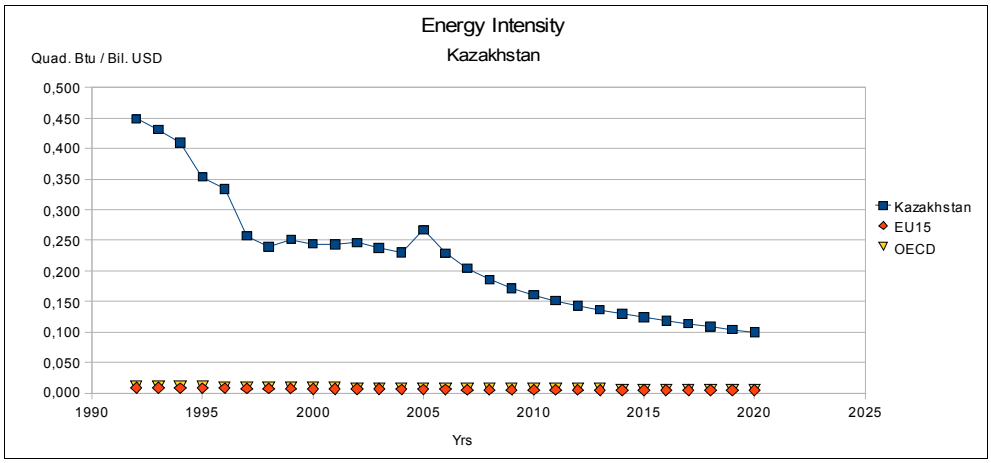
Annex: Fig. 12 – Forecast for Tajikistan's energy intensity



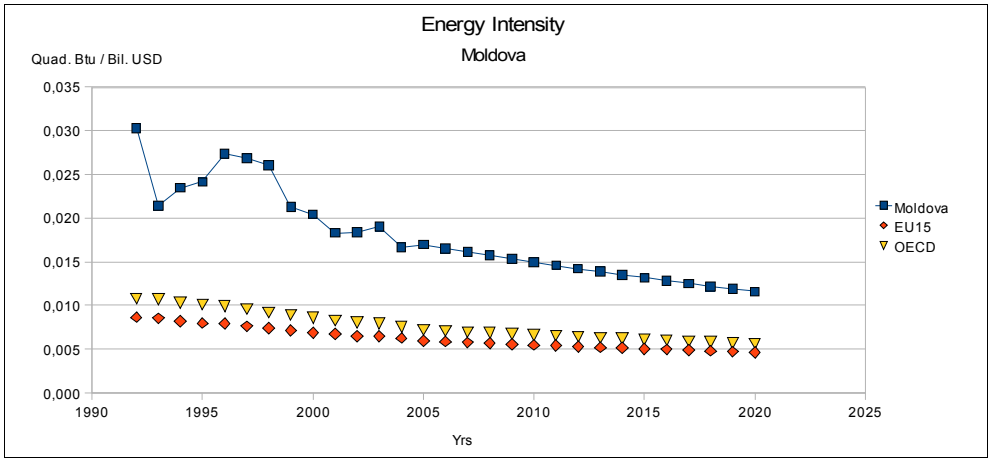
Annex: Fig. 13 – Forecast for Kyrgyzstan's energy intensity



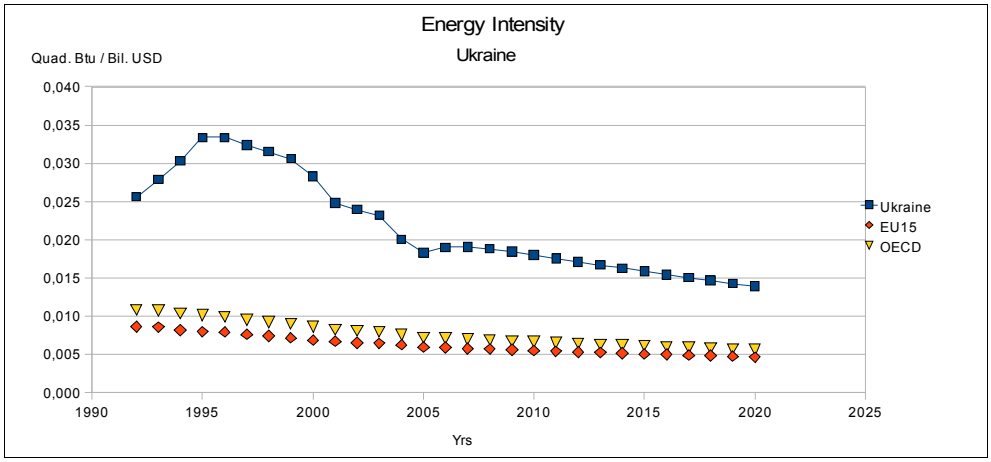
Annex: Fig. 14 – Forecast for Kazakhstan's energy intensity



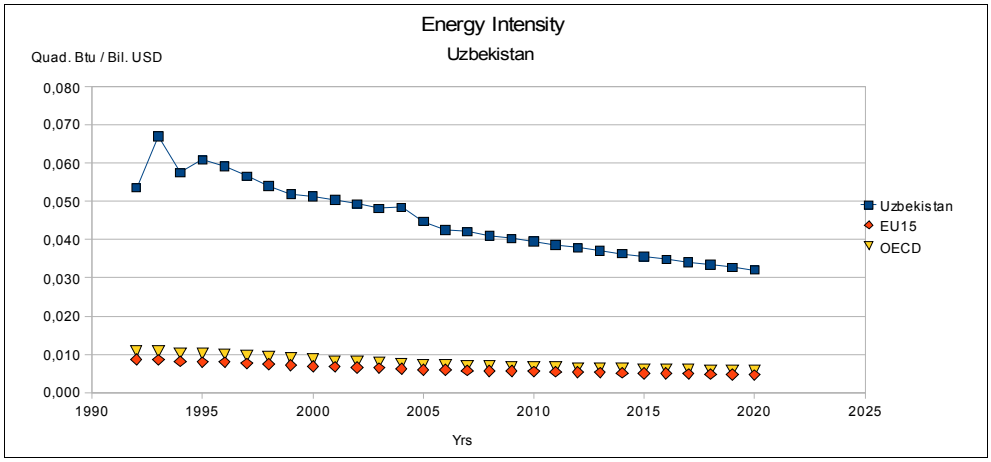
Annex: Fig. 15 – Forecast for Moldova's energy intensity



Annex: Fig. 16 – Forecast for Ukraine's energy intensity



Annex: Fig. 17 – Forecast for Uzbekistan's energy intensity



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