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The energy intensity of transition countries

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Abstract

The economies of central and eastern Europe and the former Soviet Union have traditionally been very energy intensive. Energy intensity (defined as energy use per GDP) has decreased in the course of transition, but progress has been uneven and most transition countries still use several times as much energy per unit of output as their Western peers. This paper decomposes energy data and uses panel data to identify the main factors driving improvements in energy intensity. It shows that energy prices and progress in enterprise restructuring are the two most important drivers for more efficient energy use.

Keywords: decomposition, energy intensity, energy efficiency, transition

JEL Classification Number: D2, L9, P2

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INTRODUCTION

Energy consumption in central and eastern Europe and the former Soviet Union has fallen dramatically since the beginning of transition. Much of this drop can be linked to the parallel fall in economic output, though, and in terms of energy intensity – that is, energy use per unit of output or GDP – the picture is more complex. Most transition countries have succeeded in bringing down energy intensity also, but in others energy use per GDP has, if anything, gone up. This paper seeks to identify the main factors that have driven the decline in energy intensity in some countries, and the reforms needed to encourage lower energy consumption in others.

The paper uses an arithmetic method to decompose aggregate energy data over the period 1992 to 1998 into their constituent parts. The four factors distinguished are the energy intensities of industry, transport and the rest of the economy (agriculture, services, and residential), respectively, and the effect of structural change, that is a shift in the relative importance of energy-intensive and less energy-intensive sectors within the economy.

The paper finds three distinctive patterns of energy intensity change. In a first group of countries, the energy intensity of the industrial sector went down over the study horizon, while that of the residual sector remained stable. The reverse pattern is found in a second group of countries. In a third group, which includes most of the CIS, both intensities went up or stayed stable at a very high level. Structural change generally contributed to a modest improvement in energy intensity (except in the Caucasus), reflecting the faster decline in energy-intensive sectors compared with other activities. The energy intensity of the transport sector remained more or less constant in all countries.

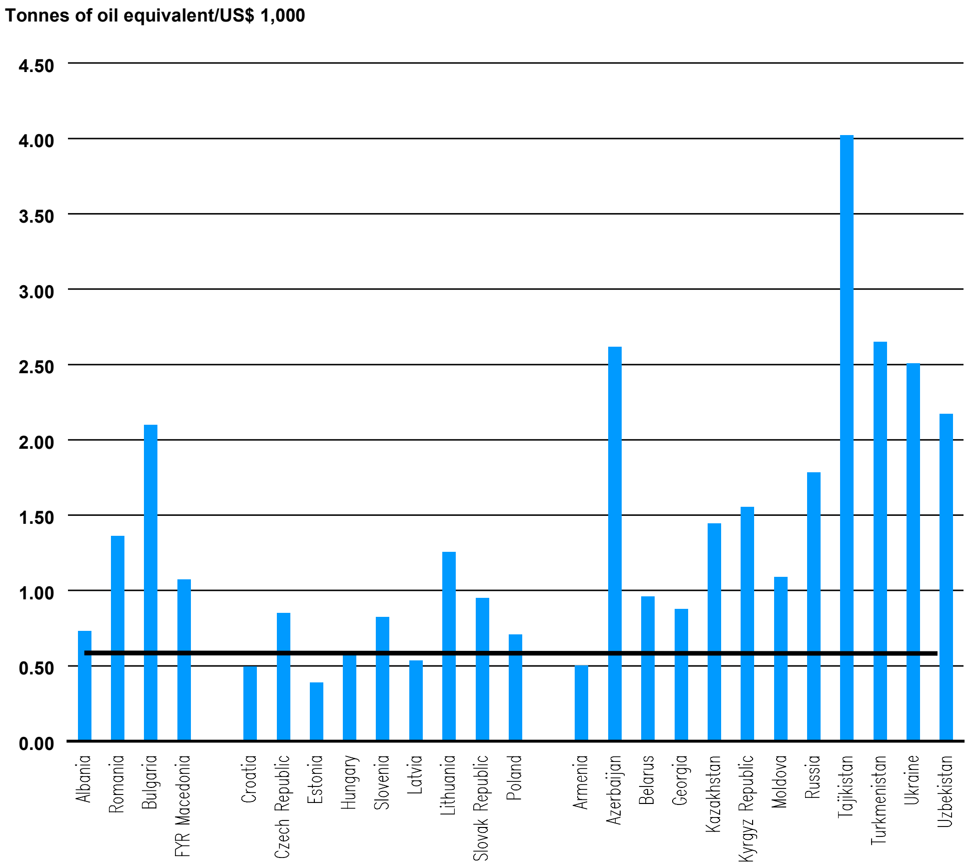
The paper then analyses the trend in industrial energy intensity econometrically. The move towards cost-reflective energy tariffs (approximated by electricity prices and collection rates, that is the effective price of power) is found to be the most important determinant of energy intensity over time. It is estimated that a doubling of energy prices could reduce industrial energy intensity by at least a third. Progress in corporate restructuring, including the enforcement of hard budget constraints, is also strongly correlated with industrial energy intensity. The analysis thus confirms the widely held belief that if the region's energy intensity is to converge towards OECD levels, transition countries will have to step up the reform process in the power sector, introduce full-cost energy pricing, and accelerate enterprise restructuring and corporate governance reform.

The difference in energy intensity between OECD countries and transition countries is sometimes seen as an indicator of the latter region's energy inefficiency. Strictly speaking, this is not correct, and differences in energy intensity should not be confused with differences in energy efficiency. Energy use depends on socio-economic and environmental circumstances – such as comparative advantages for energy-intensive activity, resource endowment, population density and climate – and energy efficiency is a measure of how resourcefully energy is used under these conditions (and given prices). The comparison of energy intensity data does not correct for different circumstances. It picks up differences in both efficiency and socio-economic conditions.

Nevertheless, the striking difference in energy intensity between OECD and transition countries suggests that substantial inefficiencies remain, whatever differences in socio-economic conditions there may be (Chart 1). The decline in energy intensity over the last decade – and the further decreases possible through market-based reform – can therefore be seen as a measure of efficiency improvements. They brought considerable economic, but also environmental benefits. It has been estimated that changes in energy use accounted for between 70 and 90 per cent of the change in air pollution and greenhouse gas emissions transition countries experienced between 1992 and 1998 (EBRD 2001).[1]

The paper is structured as follows. The next section provides the theoretical background on how to decompose aggregate energy intensity data. In Section 2 the theory is applied to transition countries for the period 1992-98. Section 3 analyses the industrial energy intensity econometrically, and Section 4 contains conclusions.

Chart 1: Energy intensity in transition countries, 1999



Source: EBRD (2001).

Note: The horizontal line shows the energy intensity of the US for comparison. GDP was not PPP-corrected. Using PPP-corrected data yields similar results although the gap to the US is smaller.

[1] A good discussion of energy and environment links in transition countries is found in Chandler (2000). Viguier (1999) uses a decomposition approach similar to the one applied here to study trends in air pollution and greenhouse gases emissions.

1. DECOMPOSING ENERGY INTENSITY

A substantial body of literature on the decomposition of energy trends has developed over recent years. The basic model commonly found in the literature decomposes energy consumption into trends in energy intensity, structural change and economic output.[2] In the current context, the interest is not so much in absolute energy consumption, however, as in changes in energy intensity. Fortunately, this change in focus only requires minimal adjustments to the basic decomposition model, as follows.

The fundamental identity underlying the energy consumption decomposition is

$$E_t = \sum_i \frac{E_{i,t}}{Y_{i,t}} \frac{Y_{i,t}}{Y_t} Y_t = \sum_i I_{i,t} s_{i,t} Y_t, \tag{1}$$

where:

$E_t =$ total energy consumption in year t

$E_{i,t} =$ energy consumption in sector i

$Y_t =$ total production

$Y_{i,t} =$ production of sector i

$s_{i,t} =$ production share of sector i $(= Y_{i,t}/Y_t)$

$I_{i,t} =$ energy intensity for sector i $(= E_{i,t}/Y_{i,t})$

Equation (1) states that the aggregate energy consumption in year *t* is the sum of the products for each sector *i* of total output, the share of the sector in total output and the energy intensity of that sector. The equivalent expression for overall (countrywide) energy intensity, I_t, is obtained by dividing equation (1) by Y_t:

$$I_t = \frac{E_t}{Y_t} = \sum \frac{E_{i,t}}{Y_{i,t}} \frac{Y_{i,t}}{Y_t} = \sum I_{i,t} s_{i,t}. \tag{2}$$

To obtain the change in energy intensity over time, equation 2 is differentiated with respect to time:

$$\frac{\partial I_t}{\partial t} = \sum \frac{\partial I_{i,t}}{\partial t} s_{i,t} + \sum I_{i,t} \frac{\partial s_{i,t}}{\partial t}. \tag{3}$$

Dividing by I_0 yields the percentage marginal change. Integrating from *0* to *t* gives the cumulative or non-marginal change between time *0* and time *t*:

$$\ln\left(\frac{I_t}{I_0}\right) = \int_0^t \sum_i \frac{\partial I_{i,t}}{\partial t} \frac{s_{i,t}}{I_0} dt + \int_0^t \sum_i \frac{I_{i,t}}{I_0} \frac{\partial s_{i,t}}{\partial t} dt. \tag{4}$$

Equation (4) represents the full decomposition of a change in energy intensity between time *0* and time *t*. However, it has the disadvantage of being tedious to calculate, and parametric

[2] This discussion is based on Ang and Lee (1994, 1996), Ang (1994, 1995), Greening et al. (1997), Sun (1998) and Zhang (2000).

techniques have therefore been developed to approximate expression (4). Generally, the preferred decomposition format is the following[3]:

$$\Delta I_{tot} = \Delta I_{\text{int}} + \Delta I_{str} + D, \qquad (5)$$

with $\Delta I_X = I_{Xt} - I_{X0}$. Hence, the change in overall energy intensity ΔI_{tot} is defined as the sum of:

- sectoral intensity effects ΔI_{int}: the change in overall energy intensity arising from the change in the sectoral energy intensities,
- the structural effect ΔI_{str}: the change in overall energy intensity arising from the change in the structure of GDP, and
- a residual D. The residual is left because the elements in equation (5) are estimated independently and hence yield an incomplete decomposition.

There are several methods to transform the integral paths stated in equation (4) into an expression like (5). The two that are perhaps most commonly used in the literature are the Parametric Divisia Method 1 (PDM1) and the Parametric Divisia Method 2 (PDM2).

PDM 1 is formulised as:

$$\begin{aligned} \Delta I_{str} &= \sum_i \left[E_{i,0}/Y_0 + \beta_i \left(E_{i,t}/Y_t - E_{i,0}/Y_0 \right) \right] \times \ln\left(s_{i,t}/s_{i,0} \right) \\ \Delta I_{\text{int}} &= \sum_i \left[E_{i,0}/Y_0 + \tau_i \left(E_{i,t}/Y_t - E_{i,0}/Y_0 \right) \right] \times \ln\left(I_{i,t}/I_{i,0} \right), \end{aligned} \qquad (6)$$

while the expression for PDM 2 is:

$$\begin{aligned} \Delta I_{str} &= \sum_i \left[I_{i,0} + \beta_i \left(I_{i,t} - I_{i,0} \right) \right] \times \left(s_{i,t} - s_{i,0} \right) \\ \Delta I_{\text{int}} &= \sum_i \left[s_{i,0} + \tau_i \left(s_{i,t} - s_{i,0} \right) \right] \times \left(I_{i,t} - I_{i,0} \right), \end{aligned} \qquad (7)$$

with $0 \le \beta_i, \tau_i \le 1$.

By choosing the value of the parameters, the integral paths in equations (6) and (7) are defined. Hence, for each of the two general methods, specific methods can be defined by assuming specific values for β_i, τ_i. Four different types of specification are found in the literature:

- $\beta_i = \tau_i = 0$ yields a Laspeyres-based method. The change in the relevant variable is measured keeping all other variables at their original level.
- $\beta_i = \tau_i = 1$ yields a Paasche index. It gives zero weight to the original year and measures the change in one of the variables while keeping the others constant at their final year level.
- with $\beta_i = \tau_i = 0.5$ variables are kept constant at a simple average. This is the simple average Divisia method.

[3] Instead of the additive formulation presented here, a multiplicative structure is sometimes used.

- an adaptive Divisia weighting method, where the weights are obtained by equalising pair-wise the equations PDM1 and PDM2. The philosophy is that both methods should yield the same results.

There is no theoretical justification for preferring either of these specifications. Instead, an empirical decision is usually taken based on the size of the residual. Consistent with the results of other studies, the average PDM 1 and 2 methods were found to give the smallest residuals as total average for all countries and all years. The average PDM 1 has a smaller variance than the average PDM 2 method and so it appears as the preferred decomposition method for this application.

2. REGIONAL ENERGY INTENSITY TRENDS

The decomposition model was applied to 22 transition countries over the period 1992 to 1998, distinguishing four constituent effects: energy intensity in the industrial sector (IND), energy intensity in the rest of the economy (including residential; ROE); energy intensity in transport (TRA) and structural change (STR). Results are presented for six regional groups[4]:

- **South-eastern Europe**, including Albania, Bulgaria, FYR Macedonia and Romania (but not Bosnia and Herzegovina and FR Yugoslavia)
- **Central Europe**, including Croatia, the Czech Republic, Hungary, Poland, the Slovak Republic and Slovenia,
- **Baltic States**, including Estonia, Latvia and Lithuania,
- **Western CIS**, including Belarus, Moldova, Russia and Ukraine,
- **Caucasus**, including Armenia and Azerbaijan (but not Georgia), and
- **Central Asia**, including Kazakhstan, the Kyrgyz Republic and Uzbekistan (but not Tajikistan and Turkmenistan).

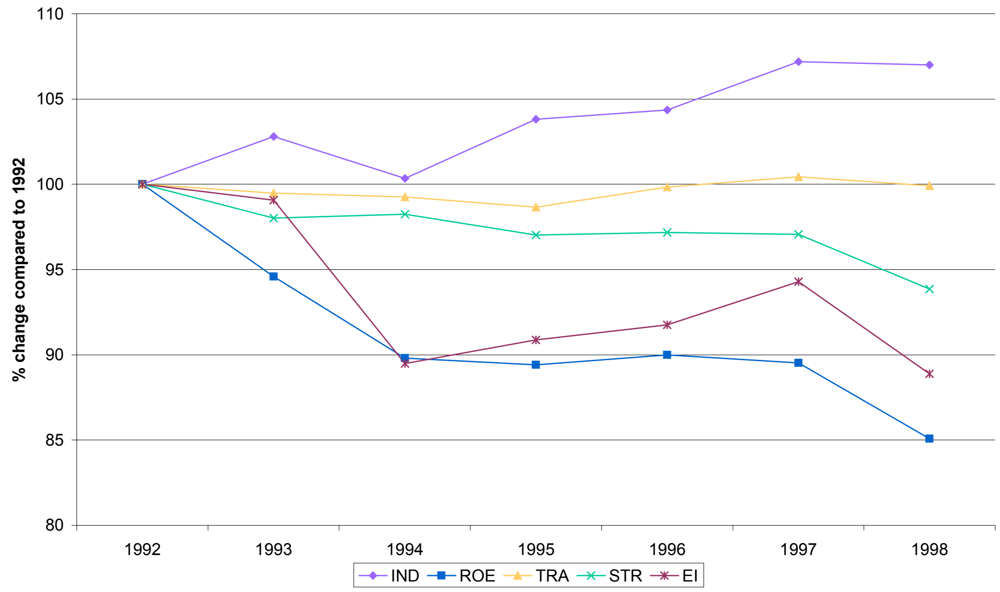
2.1 SOUTH-EASTERN EUROPE

The overall energy intensity (EI) in the four South-east European states considered here declined in the early years of transition, but started to climb back between 1995 and 1997, before beginning to drop again. In 1998, energy intensity was down 14 per cent compared with 1992.

The picture for South-eastern Europe is dominated by events in Bulgaria and Romania. It shows two opposite tendencies (Chart 2). On the one hand, non-industrial energy use and structural change contributed to a reduction in energy intensity. Industrial energy intensity, on the other hand, increased by 19 per cent over the study period, a reflection of the slow pace in privatisation and restructuring which both Bulgaria and Romania experienced over much of the decade.

[4] The decomposition was made using data from the International Energy Agency (IEA) and the US Energy Information Administration (US EIA). For GDP the constant (but not PPP-corrected) 1995-dollar time series from the World Development Indicators (WDI) was used. An important adjustment concerns the treatment of secondary energy. Data on total primary energy supply treat the transformation sector (power and heat generation, refining) as a separate consumer of primary energy. For an analysis at the end-user level, it was necessary to allocate primary energy use in the transformation sector to the sectors where the final consumption of the transformed energy takes place. This was done using the share in total electricity of each sector as weights.

Chart 2: Decomposition of energy intensity, South-eastern Europe



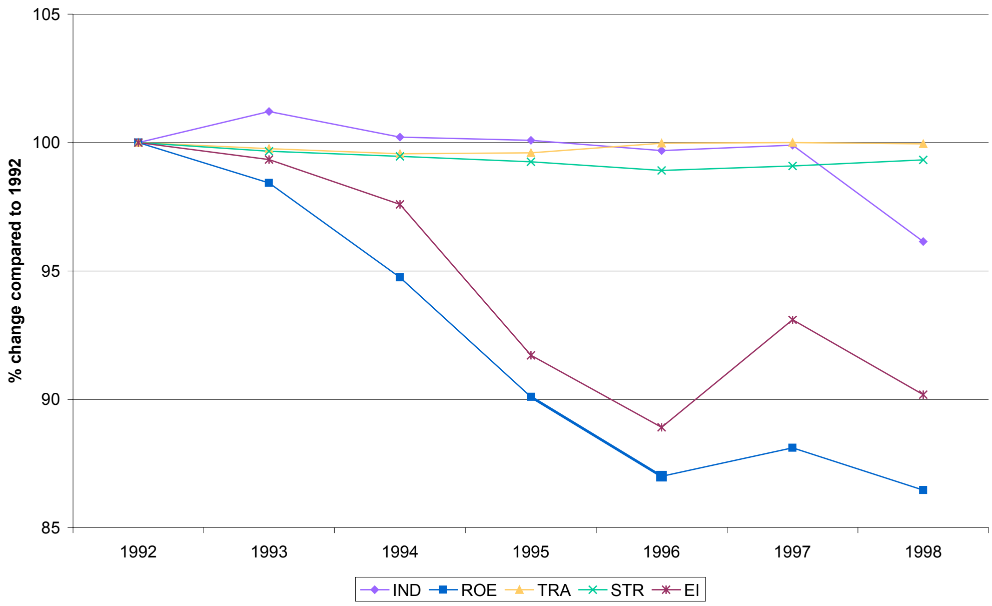
Source: Own calculations, based on IEA, US EIA, and WDI data.
See the Annex for full summary table.

2.2 CENTRAL EUROPE

Energy intensity in Central Europe decreased from 0.84 kilogram of oil equivalent per dollar (kgoe/US$) in 1992 to 0.69 kgoe/US$ in 1998 – the lowest level of all sub-regions, but still well above the 1998 EU level of 0.17 kgoe/US$. The decline in total energy intensity was predominantly due to a sharp and continuous decrease in ROE energy intensity. Industrial energy intensity barely changed until 1997, and the effect of structural change was less than 1 per cent (Chart 3).

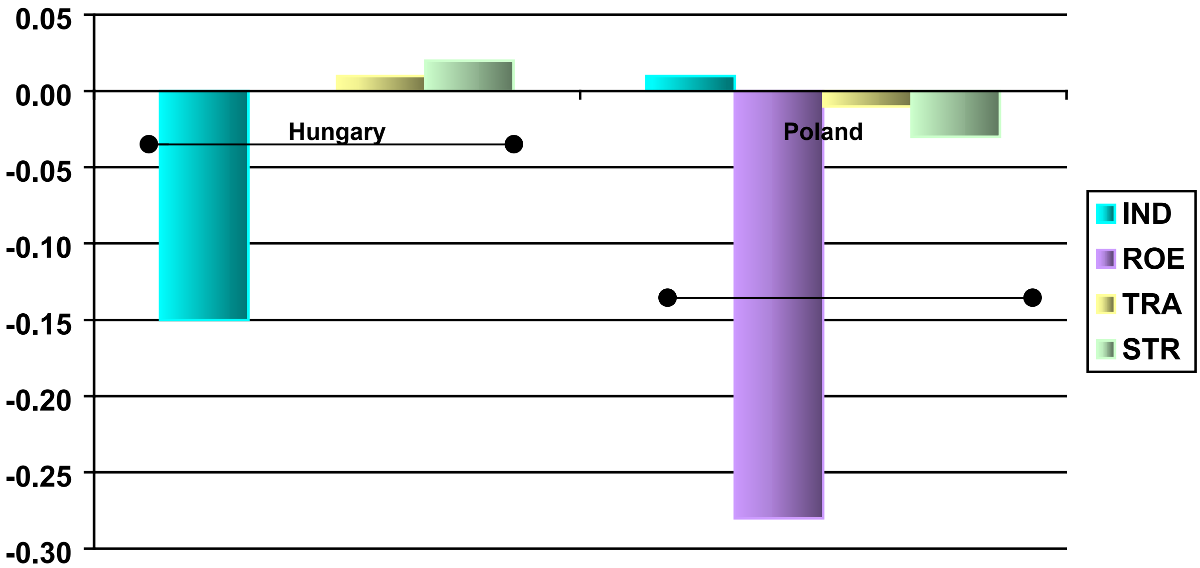
The Central European average masks substantial differences between countries such as Hungary and Poland, as shown in Chart 4. Poland was the first transition country to return to growth and to again reach its pre-transition GDP level. This was achieved by taking a relatively cautious approach on privatisation and restructuring in certain strategic sectors, and this may explain the slow progress in industrial energy intensity between 1992 and 1998.

Chart 3: Decomposition of energy intensity, Central Europe



Source: Own calculations, based on IEA, US EIA, and WDI data.

Chart 4: Energy decomposition in Hungary and Poland (1992-98)



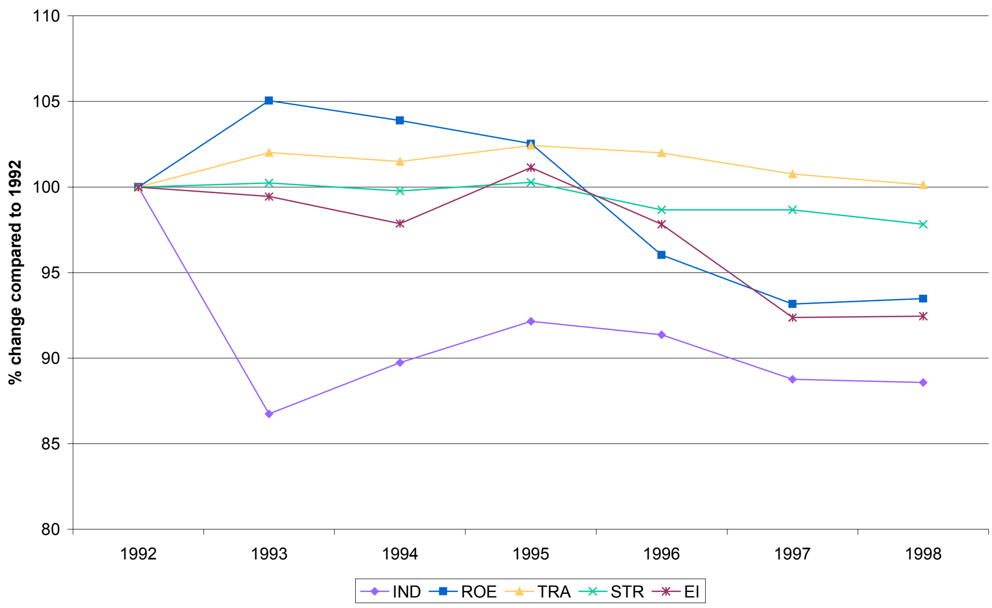
Source: Own calculations, based on IEA, US EIA, and WDI data.
Note: The horizontal lines show the total changes EI in each country. See the Annex for full summary table.

In Hungary, in contrast, economic recovery went hand in hand with a de-coupling of industrial production and energy consumption, so that by 1998 industrial energy intensity was 15 per cent below its 1992 level. Energy intensity in ROE picked up temporarily but then dropped again so that the net change between 1992 and 1998 is zero.

2.3 BALTIC STATES

In the Baltic States, both output and total energy consumption remained below 1992 levels throughout the study period. But while output started to recover after 1994, energy consumption kept declining, resulting in a de-coupling of production and energy use, and hence an improved overall energy intensity. The decrease in industrial energy intensity accounts for about half this decline (Chart 5).

Chart 5: Decomposition of energy intensity, Baltic States



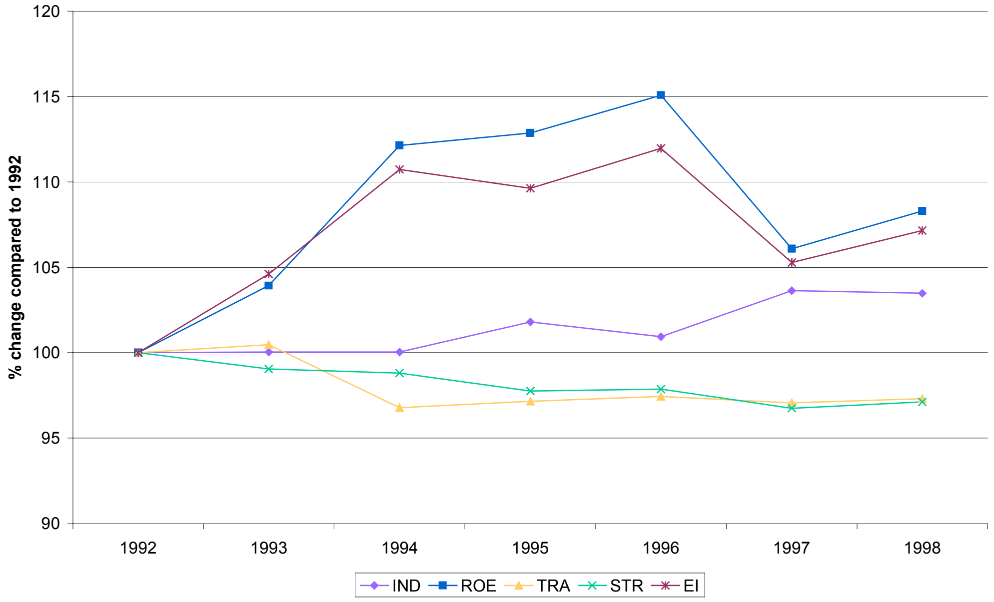
Source: Own calculations, based on IEA, US EIA, and WDI data.
See the Annex for full summary table.

Again, there are differences between countries, with Estonia showing few signs of a de-coupling in the industrial sector, while in Latvia the energy intensity of both the industrial sector and the rest of the economy decreased. Lithuania experienced a decrease only in the energy intensity of industry, but not that of the rest of the economy (see the Annex for details).

2.4 WESTERN CIS

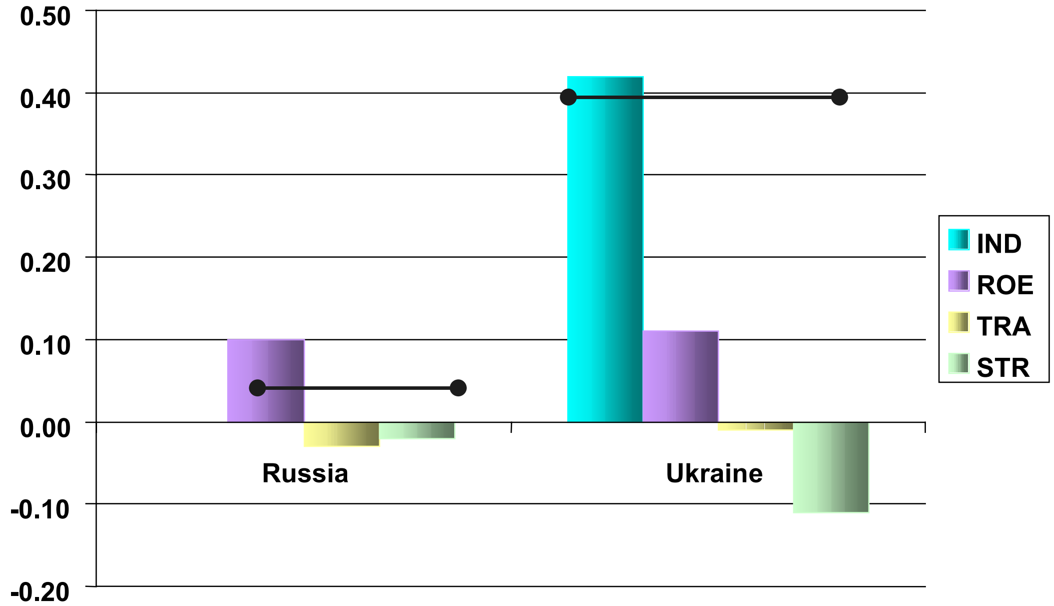
The picture found in the Western CIS (Chart 6) holds for all countries of this sub-region. There are few differences between countries. When the economy collapsed after the break-up of the Soviet Union, energy consumption did not decrease proportionately and the energy intensity in both industry and ROE increased further from an already high level. Only structural change and transport helped to dampen the upward trend somewhat.

Chart 6: Decomposition of energy intensity, Western CIS



Source: Own calculations, based on IEA, US EIA, and WDI data.
See the Annex for full summary table.

Chart 7: Energy decomposition in Russia and Ukraine



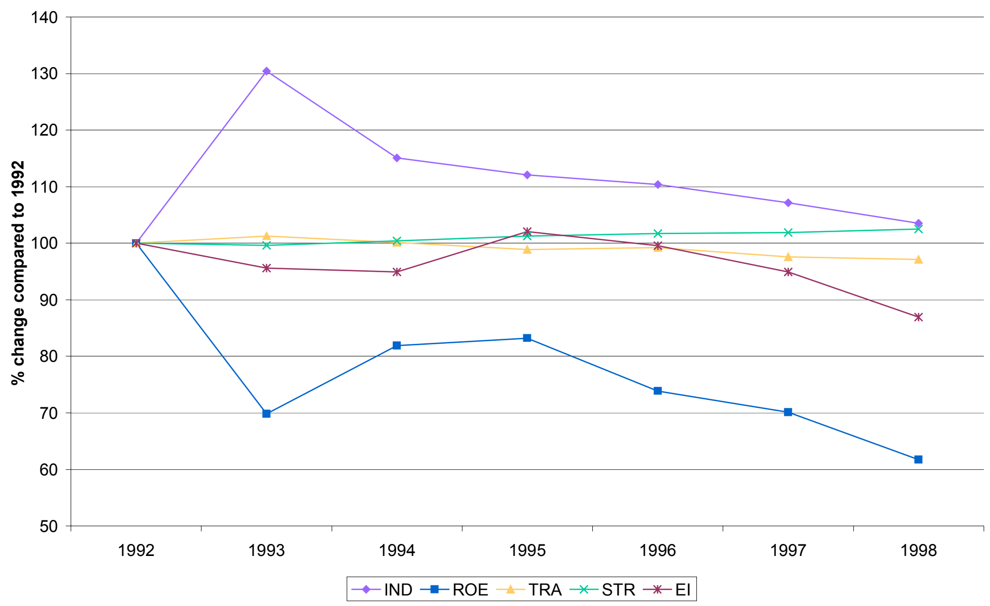
Source: Own calculations, based on IEA, US EIA, and WDI data.
Note: The horizontal lines show the total changes EI in each country. See the Annex for full summary table.

The most significant increase in industrial energy intensity was observed in Ukraine, where energy use per unit of output grew by 42 per cent to a staggering 3.6 kgoe/US$ or more than 20 times the EU level.[5] In Russia industrial energy intensity remained almost constant, but ROE accounted for an increase in total energy intensity of 10 per cent in 1998 (Chart 7).

2.5 CAUCASUS

Armenia and Azerbaijan – the two Caucasus countries covered in the analysis – experienced a 32 per cent decrease in energy intensity between 1992 and 1998, much of it due to developments in the non-industrial sector. ROE energy intensity fell sharply in both countries and by 1998 accounted for a 36 per cent decrease in total regional energy intensity (Chart 8). Industrial energy intensity stayed constant or even increased. However, because of the relatively small share of industry in the GDP, the change in industrial energy intensity accounted for only a 4 per cent rise in total energy intensity. Poor data may be partly to blame for the surprisingly large extent of these swings. Statistics for the period of the Nagorno Karabakh war (which ended in 1994) in particular are less than reliable.

Chart 8: Decomposition of energy intensity, Caucasus



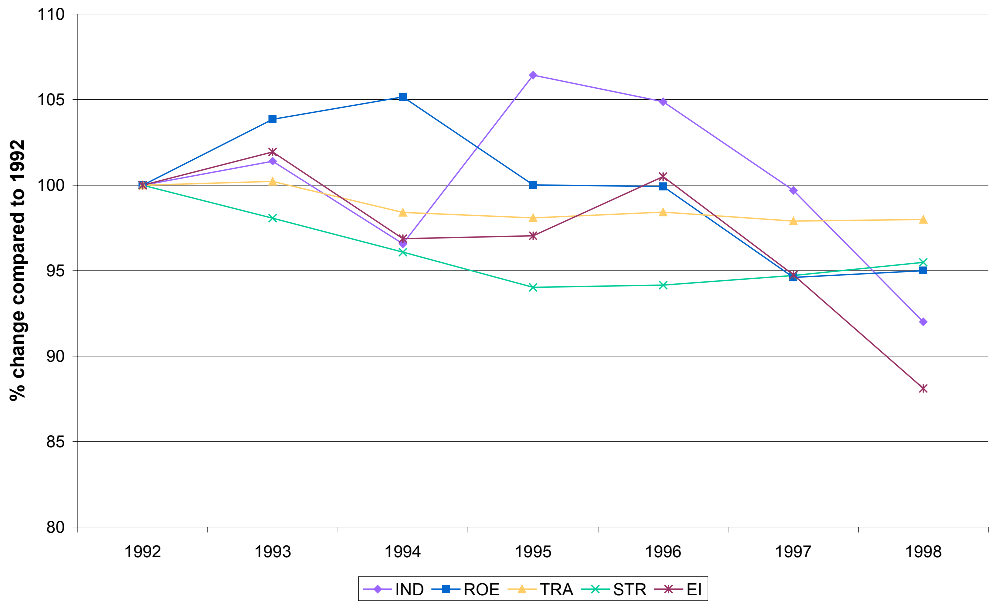
Source: Own calculations, based on IEA, US EIA, and WDI data.
See the Annex for full summary table.

5 The data for CIS and some south-east European countries are less reliable than that for the rest of the region. In these countries substantial parts of the economy have shifted to the informal sector, with their energy use being counted but not the output value. Hence, actual energy intensity might be lower than shown in statistical tables.

2.6 Central Asia

Following a slow start, total energy intensity in Central Asia started to decrease rapidly after 1996 – the effect of a parallel drop in industrial and ROE energy intensities. Structural change played a stronger, but still modest role, compared with other sub-regions (Chart 9). Again, data problems are evident, particularly in earlier years. The regional picture is dominated by developments in Kazakhstan, whose energy intensity was amongst the highest in the region at 3.01 kgoe/US$ in 1992, but decreased to 1.84 kgoe/US$ in 1998, slightly less than the CIS average. The reduction in energy consumption mainly happened in the industrial sector where an economic contraction combined with a steep decline in energy consumption resulted in a decrease in energy intensity of 50 per cent, accounting for a 25 per cent reduction of total energy intensity compared with 1992 levels.

Chart 9: Decomposition of energy intensity, Central Asia



Source: Own calculations, based on IEA, US EIA, and WDI data.
See the Annex for full summary table.

3. THE DRIVERS OF INDUSTRIAL ENERGY INTENSITY

The decomposition of energy intensity undertaken in Section 3 is a purely descriptive exercise. It shows how energy use per unit of output has changed in different parts of the economy, but cannot offer many insights into the factors driving these changes. To better understand the main drivers of change in energy intensity, this section looks at the link between industrial energy intensity and key reform parameters, such as privatisation, enterprise restructuring and power sector reform. Progress is measured by the EBRD transition indicators for these reform categories, as published in the EBRD's *Transition Reports* (see for example EBRD 2001).[6] The importance of price signals is tested by regressing energy intensity against power tariffs and collection rates.

Because of the difficulty in finding good price data, the analysis uses two different data sets. A first panel makes use of OECD statistics on industrial electricity prices in the Czech Republic, Hungary, Poland, the Slovak Republic, Russia and Kazakhstan for 1992-98. The second, full panel makes use of EBRD statistics for power tariffs and collection rates from 1994 until 1998. This data set includes all transition countries but is less accurate as the data are for average electricity prices across consumer groups.

3.1 PANEL DATA REGRESSIONS

A first set of regressions uses the OECD data set for panel analysis and relates industrial energy intensity to electricity prices and two transition indicators: large-scale privatisation, and corporate governance and restructuring. The tariff variable tests the importance of price signals, while the two transition indicators were chosen to test the assertion that private ownership (in particular of the large energy users) and enterprise reform result in more efficient resource use, and hence a lower energy intensity. The model can be written as:

$$ei_{it} = \alpha + \beta' p_{it} + \delta GER_{it} + \gamma LSP_{it} + u_i + \varepsilon_{it}, \qquad (8)$$

where ei_{it} = industrial energy intensity, p_{it} = industry electricity price, GER_{it} = the EBRD transition indicator for governance and enterprise restructuring and LSP_{it} = the EBRD transition indicator for large-scale privatisation for country *i* in year *t*. A random effect approach is used, which assumes that individual country constants u_i are randomly distributed across cross-sectional units. This is opposed to the fixed effects approach, which treats country differences as constant parametric shifts of the regression function. Generally, the random effects estimator is preferred in the presence of measurement errors. A Hausman specification test was carried out to confirm that individual country effects are not correlated with other regressors, a key condition in the random effect model.

[6] The EBRD's transition indicators provide an ordinal measure of a country's progress with respect to a particular transition challenge, such as large-scale privatisation, price liberalisation or power sector reform. Progress is measured on a scale from 1 (no progress) to 4+ (fully functioning market economy).

Table 1: Results for panel regression

	Coefficient	t	Elasticity
P	-15.73454	-2.708	-0.34
GER	-0.4975505	-2.188	-0.65
LSP	0.2209837	1.490	-0.36
CONS	3.031665	5.872	
R-sq within = 0.1787 between = 0.8531 overall = 0.7123 Number of obs = 42			

Source: Own calculations. The elasticities are calculated based on the average values over time and countries.

Table 1 shows the results of this first regression. The price variable is negative, meaning that an increase in prices over time or cross-sectionally leads to a decrease in energy intensity. The variable is highly significant: a 100 per cent increase, or doubling, of energy prices is estimated to lead to a 34 per cent reduction in energy intensity. The governance and restructuring variable is also significant and has a negative sign, as one would expect. This finding is reinforced when a lagged governance and restructuring variable is added. Both the lagged and non-lagged variables are highly significant and negative when included jointly.[7] The large-scale privatisation variable has the opposite sign of what one would expect, but is not very significant. The estimator is better at explaining the between variance – that is, the variance between countries – than the within variance – that is, the evolution over time.

However, the fact that the LSP variable is barely significant and its sign counterintuitive, combined with the high R^2, points at possible multi-collinearity between GER and LSP. This is confirmed when leaving one of the two transition indicators out of the regression. Deleting the LSP variable decreases the effect of the GER variable and vice versa. One interpretation of this is that the correlation is not only between GER and LSP, but between these two variables and electricity prices. This is intuitively appealing, as one would expect energy tariff reform to trigger further restructuring as industries react to the new price signal. It is also possible that part of the trend shown by the transition indicators is captured by individual country effects. The predicted fixed country effects vary from –1.2 for Hungary to +2 for Russia (Table 2), which is a large variation for industrial intensities ranging from 0.35 to 5.3. Table 2 confirms the similarity between the fixed effects and the GER variable.

[7] Other lagged variables have not been found to be significant, neither when entered separately or jointly.

Table 2: Fixed country effects

	Fixed effect	GER (1999)
Hungary	-1.1456	3.5
Poland	-1.20455	3
Czech Republic	-0.65902	3
Slovak Republic	-0.28617	3
Kazakhstan	0.61421	2
Russian Federation	2.681131	1.5

Source: Own calculations, EBRD.

The tentative conclusion from the first set of panel data regressions is that the electricity price can explain both the time trend and the cross-sectional variance of industrial energy intensity, while the GER transition indicator or the fixed country effects determine the substantial variation in the level of intensity cross-sectionally.

3.2 Pooled regression

In a second regression, the OECD price data for six countries are used for pooled analysis. A new variable – the EBRD transition indicator for progress in power sector reform in 1998 (ELECTI) – is introduced as a proxy for fixed individual country effects.[8] The model specification is:

$$ei_{it} = \alpha + \beta p_{it} + \delta LSP_{it} + \phi GER_{it} + \gamma ELECTI_i + \varepsilon_{it}. \quad (9)$$

The results are shown in Table 3. All four variables are highly significant and three of them have a negative sign. The adjusted R^2 is 77 per cent. The conclusion from these calculations is that increasing electricity prices and progress in enterprise restructuring and corporate governance drive the decline in industrial energy intensity. The level of energy intensity is also highly correlated with the level of reform in the power sector. The impact of privatisation is again small (and positive), suggesting that privatisation without subsequent restructuring is not enough to improve energy intensity.

Table 3: Results for pooled regression

	Coefficient	t	Elasticity
P	-34.12697	-4.150	-0.73
GER	-1.290593	-4.959	-1.69
LSP	.7880303	3.671	1.28
ELECTI	-.5239572	-3.128	-0.75
CONS	5.37849	7.687	
Adj R-squared = 0.7710			

Source: Own calculations.

8 This new variable is preferred to the GER (1999) fixed effect because the latter variable is heavily correlated with the time-varying GER variable. Hence, only one of the two GER variables is highly significant. When no fixed effect is included, the GER and LSP are both highly significant, suggesting that these two variables account for the fixed effect.

3.3 THE EBRD PANEL

In a third set of regressions, the OECD electricity price data are replaced by the EBRD data set, creating a panel with a larger cross-section of countries but a shorter time span (1994-98). Prices are average electricity prices, not specifically industry prices. The EBRD data set also includes data on collection rates, and the two variables are combined in a multiplicative term, PCOL, to reflect the fact that the effective price paid for electricity is the product of price times collection rate.

The LSP variable is replaced by a new term, EMP, which measures the ratio of actual employment to the benchmark employment for a country's industry.[9] EMP is a measure of overstaffing. The assumption is that companies which use one input (labour) inefficiently will also be wasteful with others, and can afford to be so because of soft budget constrains. EMP is thus a proxy for soft budget constraints. The model now is:

$$ei_{it} = \alpha + \beta PCOL_{it} + \delta EMP_{it} + \phi GER_{it} + \gamma(ELECTI_i) + \varepsilon_{it}. \quad (10)$$

The model specification can explain 35 per cent of the industrial energy intensity pattern. Using the effective price variable, PCOL, gives a better fit than adding separate terms for price and collection rates, but the variable is still only significant at the 80 per cent level (Table 4). This is probably a reflection of the fact that price and collection data are a country average instead of industry specific. The governance and restructuring indicator GER is again highly significant and negative. The soft budget constraint proxy EMP is significant at the 8 per cent level. Hence, the hypothesis that soft budget constraints have an important negative impact on energy intensity is supported.

Table 4: Results for the EBRD panel

	Coefficient	t	Elasticity
PCOL	-.002504	-1.296	-0.17
GER	-3.536828	-5.174	-2.02
EMP	-1.974152	-1.755	-0.61
ELECTI	1.485997	2.413	
CONS	11.37986	5.031	
Adj R-squared = 0.3535			

Source: Own calculations.

[9] The benchmark employment figure is based on an international assessment and comparison of the staff needed to manage certain technologies and industrial processes.

4. CONCLUSION

The energy intensities of transition countries, which have historically been very high compared with other industrialised economies, have started to come down since the beginning of transition. The extent of this decline varies greatly, however, and even the least energy-intensive countries of the region still use substantially more energy per GDP than do their OECD peers. Against this backdrop, this paper analysed the factors that are driving the decline in energy intensity in transition countries, and asked what reforms are needed to get the region's energy intensity closer to that of other advanced economies.

The decomposition of energy intensity data showed different patterns in the evolution of energy intensity over the last decade. In a first group of countries, which includes for example Hungary, Latvia and Slovenia, the energy intensity of industry came down sharply, but that of the rest of the economy decreased less or remained stable. Although it is hard to generalise, the countries in this group typically moved fast on privatisation, price liberalisation and corporate restructuring. Consequently, industrial output and energy use was de-coupled during the mid-1990s and industrial energy intensity began to decrease. The energy intensity in the non-industrial part of the economy declined where it had been high at the beginning of transition (for example, in Latvia) but remained constant in countries that had a higher level of efficiency at the outset (for example, Hungary and Slovenia).

In a second group of countries, including for example Poland, Romania and the Slovak Republic, the picture is reversed: the energy intensity of industry remained constant, but that of the rest of the economy improved. These countries tend to be characterised by a large share of heavy industry in GDP and a certain reluctance by their governments to tackle the politically delicate restructuring of these sectors, although some of them made good progress in other reform areas.

In a third group of countries, which includes most of the CIS, the energy intensity of both industry and the rest of the economy went up in the course of transition, and sometimes dramatically so. In these countries privatisation and enterprise restructuring were either delayed, or the privatisation process was flawed and did not result in the necessary inflow of new capital and know how. Industry continued to benefit from soft budget constraints either through state subsidies or the tolerance of tax and utility arrears (or both). Non-payment of energy bills also remained a problem in the non-industrial sectors, so that neither industry nor the rest of the economy had an incentive to bring down energy intensities.

The pattern with respect to the remaining decomposition factors is more uniform. Structural change was beneficial in most countries but its contribution to changes in overall energy intensity was generally modest. The energy intensity of the transport sector also remained more or less constant throughout the region.

An explanation for some of these patterns can be found in the econometric analysis of industrial energy intensity. The regressions show a strong correlation between industrial energy intensity and the level of electricity prices. Particularly in the CIS, electricity tariffs have been kept below cost-recovery level and are only now gradually adjusted. This removed much of the incentives industry might have had to use energy efficiently. There is also evidence that the level of power sector reform more broadly can help to explain differences in industrial energy intensity. While this may simply reflect the fact that power sector and tariff reform often go hand in hand, it reinforces the message that the thorough reform of the power sector – including tariff adjustments, unbundling and the introduction of commercial discipline – is an important precondition for more efficient energy use.

The negative effect of low power tariffs is exacerbated by the lack of corporate restructuring and reform. There is both cross-sectional and time series evidence that enterprise restructuring and governance reform are crucial to create an environment under which energy intensities can improve. The countries that are most advanced in corporate reform have the lowest energy intensities, and the governance and enterprise reform variable was among the most significant in all regressions. The evidence also underlines the importance of hard budget constraints, including adequate tariff collection levels, the phasing out of subsidies to loss-making firms and the vigorous enforcement of bankruptcy laws.

The analysis further points at the importance of capital and know-how as key drivers in the reform process. While there is a clear correlation between enterprise restructuring and energy use, there is little evidence that privatisation, on its own, will reduce energy intensity. This is consistent with the notion that private ownership, *per se*, is not sufficient to effect the necessary technological and managerial improvements in an ailing company. Privatisation is only successful if ownership is transferred to the right party – a committed and competent investor with access to the necessary capital.

Overall, the paper finds a strong link between improvements in energy intensity and progress in transition. This should not surprise, as transition is chiefly about creating structures and incentives for the efficient use of resources, and energy is a crucial resource in transition countries. There is thus a strong overlap between the policies needed to improve energy intensity and some of the region's key transition challenges. The fact that transition countries still lag behind in the energy intensity stakes suggests that they have not yet reached the end of the road toward full-functioning market economies.

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ANNEX: DECOMPOSITION OF ENERGY INTENSITY BY COUNTRY

The tables show the contribution of four factors to changes in overall energy intensity (EI) since 1992: the energy intensities of industry (IND), the rest of the economy (ROE) and Transport (TRA), and the effect of structural change (STR). For instance, Albania's overall energy intensity decreased by 33 per cent between 1992 and 1997.

South-eastern Europe

		1992	1993	1994	1995	1996	1997	1998
Albania	IND	0.00	0.02	-0.12	-0.18	-0.16	-0.19	-0.19
	ROE	0.00	-0.13	-0.14	-0.08	-0.08	-0.10	-0.14
	TRA	0.00	-0.01	0.01	0.01	0.01	0.01	0.01
	STR	0.00	-0.06	-0.07	-0.07	-0.06	-0.06	-0.07
	EI	***0.00***	***-0.18***	***-0.31***	***-0.31***	***-0.29***	***-0.33***	***-0.39***
Bulgaria	IND	0.00	0.02	0.07	0.07	0.17	0.29	0.17
	ROE	0.00	-0.05	-0.11	-0.08	-0.03	-0.09	-0.12
	TRA	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	STR	0.00	-0.01	-0.04	-0.03	-0.04	-0.10	-0.08
	EI	***0.00***	***-0.06***	***-0.08***	***-0.04***	***0.09***	***0.11***	***0.00***
FYR Macedonia	IND	0.00	0.05	-0.02	0.02	0.12	0.02	0.05
	ROE	0.00	0.06	-0.01	0.02	0.09	0.02	0.12
	TRA	0.00	0.00	0.02	0.01	0.09	0.07	0.02
	STR	0.00	-0.01	-0.02	-0.07	-0.06	-0.05	-0.04
	EI	***0.00***	***0.09***	***-0.04***	***-0.01***	***0.23***	***0.05***	***0.14***
Romania	IND	0.00	0.03	-0.02	0.03	0.00	0.01	0.05
	ROE	0.00	-0.05	-0.08	-0.10	-0.11	-0.09	-0.15
	TRA	0.00	-0.01	-0.01	-0.02	-0.01	0.00	-0.01
	STR	0.00	-0.03	-0.01	-0.04	-0.03	-0.02	-0.09
	EI	***0.00***	***-0.05***	***-0.14***	***-0.13***	***-0.15***	***-0.10***	***-0.19***
South-eastern	IND	0.00	0.03	0.00	0.04	0.04	0.07	0.07
Europe	ROE	0.00	-0.05	-0.09	-0.09	-0.09	-0.09	-0.13
	TRA	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00
	STR	0.00	-0.03	-0.03	-0.04	-0.04	-0.04	-0.09
	EI	***0.00***	***-0.05***	***-0.12***	***-0.11***	***-0.09***	***-0.06***	***-0.14***

Central Europe

		1992	1993	1994	1995	1996	1997	1998
Croatia	IND	0.00	0.01	0.02	-0.03	-0.06	-0.07	-0.07
	ROE	0.00	0.06	0.13	0.13	0.10	0.07	0.10
	TRA	0.00	0.01	0.02	0.02	0.02	0.03	0.03
	STR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	EI	***0.00***	***0.10***	***0.13***	***0.07***	***0.02***	***-0.02***	***0.01***
Czech Republic	IND	0.00	0.00	-0.01	-0.02	-0.06	-0.07	-0.08
	ROE	0.00	-0.08	-0.07	-0.07	-0.03	-0.02	-0.01
	TRA	0.00	-0.01	0.00	-0.01	0.00	0.00	0.01
	STR	0.00	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01
	EI	***0.00***	***-0.10***	***-0.11***	***-0.13***	***-0.10***	***-0.09***	***-0.08***
Hungary	IND	0.00	-0.03	-0.07	-0.09	-0.09	-0.12	-0.15
	ROE	0.00	0.03	0.03	0.04	0.05	0.02	0.00
	TRA	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	STR	0.00	0.00	0.01	0.01	0.01	0.01	0.02
	EI	***0.00***	***0.00***	***-0.03***	***-0.04***	***-0.03***	***-0.09***	***-0.12***
Poland	IND	0.00	0.03	0.02	0.05	0.05	0.07	0.01
	ROE	0.00	-0.03	-0.10	-0.21	-0.28	-0.24	-0.26
	TRA	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
	STR	0.00	0.00	0.00	-0.02	-0.04	-0.03	-0.03
	EI	***0.00***	***0.00***	***-0.09***	***-0.18***	***-0.26***	***-0.20***	***-0.28***
Slovak Republic	IND	0.00	0.01	0.10	-0.06	-0.03	0.01	0.02
	ROE	0.00	0.06	0.01	0.09	0.04	-0.03	-0.08
	TRA	0.00	0.00	-0.04	0.01	0.00	-0.01	-0.01
	STR	0.00	-0.01	-0.06	0.00	-0.02	-0.07	-0.09
	EI	***0.00***	***0.07***	***0.03***	***0.05***	***-0.01***	***-0.09***	***-0.14***
Slovenia	IND	0.00	0.01	0.04	0.01	0.03	-0.03	-0.05
	ROE	0.00	0.05	0.00	0.00	0.06	0.02	0.01
	TRA	0.00	-0.01	0.04	0.05	0.07	0.07	0.08
	STR	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	EI	***0.00***	***0.04***	***0.07***	***0.05***	***0.14***	***0.05***	***0.03***
Central Europe	IND	0.00	0.01	0.00	0.00	0.00	0.00	-0.04
	ROE	0.00	-0.02	-0.05	-0.09	-0.12	-0.11	-0.13
	TRA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	STR	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.01
	EI	***0.00***	***-0.01***	***-0.06***	***-0.11***	***-0.14***	***-0.13***	***-0.18***

Baltic States

		1992	1993	1994	1995	1996	1997	1998
Estonia	IND	0.00	-0.11	-0.03	0.07	0.18	0.15	0.16
	ROE	0.00	0.07	-0.02	-0.06	-0.08	-0.05	-0.04
	TRA	0.00	0.01	0.07	0.07	0.06	0.05	0.04
	STR	0.00	-0.01	-0.02	-0.05	-0.09	-0.09	-0.13
	EI	***0.00***	***0.00***	***0.01***	***0.07***	***0.06***	***0.05***	***0.03***
Latvia	IND	0.00	-0.14	-0.11	-0.12	-0.05	-0.09	-0.09
	ROE	0.00	-0.06	-0.10	-0.03	-0.09	-0.17	-0.19
	TRA	0.00	0.03	-0.01	0.00	-0.01	-0.03	-0.04
	STR	0.00	0.00	-0.01	0.00	0.00	0.01	-0.01
	EI	***0.00***	***-0.16***	***-0.22***	***-0.13***	***-0.14***	***-0.28***	***-0.33***
Lithuania	IND	0.00	-0.12	-0.10	-0.07	-0.17	-0.19	-0.20
	ROE	0.00	0.12	0.17	0.11	0.04	0.04	0.06
	TRA	0.00	0.02	0.02	0.04	0.04	0.03	0.03
	STR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	EI	***0.00***	***0.01***	***0.09***	***0.07***	***-0.10***	***-0.13***	***-0.12***
Baltic States	IND	0.00	-0.13	-0.10	-0.08	-0.09	-0.11	-0.11
	ROE	0.00	0.05	0.04	0.03	-0.04	-0.06	-0.06
	TRA	0.00	0.02	0.01	0.02	0.02	0.01	0.00
	STR	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02
	EI	***0.00***	***-0.06***	***-0.05***	***-0.03***	***-0.12***	***-0.18***	***-0.20***

Western CIS

		1992	1993	1994	1995	1996	1997	1998
Belarus	IND	0.00	0.07	0.02	0.05	0.01	-0.01	-0.04
	ROE	0.00	-0.15	-0.12	-0.08	-0.07	-0.12	-0.16
	TRA	0.00	-0.01	-0.05	-0.05	-0.05	-0.06	-0.05
	STR	0.00	-0.04	-0.04	-0.03	-0.01	-0.02	-0.02
	EI	***0.00***	***-0.08***	***-0.13***	***-0.07***	***-0.09***	***-0.18***	***-0.24***
Moldova	IND	0.00	-0.15	0.02	-0.03	0.01	0.08	-0.04
	ROE	0.00	-0.15	-0.15	-0.16	-0.12	-0.11	-0.03
	TRA	0.00	0.00	-0.05	-0.06	-0.06	-0.07	-0.07
	STR	0.00	0.00	0.00	0.00	0.00	-0.02	0.04
	EI	***0.00***	***-0.32***	***-0.17***	***-0.22***	***-0.14***	***-0.08***	***-0.10***
Russia	IND	0.00	-0.05	-0.04	-0.02	-0.04	-0.01	0.00
	ROE	0.00	0.07	0.14	0.14	0.16	0.07	0.10
	TRA	0.00	0.01	-0.04	-0.03	-0.03	-0.03	-0.03
	STR	0.00	0.00	0.00	-0.02	-0.01	-0.03	-0.02
	EI	***0.00***	***0.03***	***0.06***	***0.06***	***0.08***	***0.00***	***0.04***
Ukraine	IND	0.00	0.29	0.23	0.25	0.37	0.40	0.42
	ROE	0.00	-0.06	0.07	0.17	0.16	0.13	0.11
	TRA	0.00	-0.01	-0.01	0.00	-0.01	-0.01	-0.01
	STR	0.00	-0.13	-0.05	-0.01	-0.06	-0.09	-0.11
	EI	***0.00***	***0.13***	***0.24***	***0.41***	***0.44***	***0.42***	***0.40***
Western CIS	IND	0.00	0.00	0.00	0.02	0.01	0.04	0.03
	ROE	0.00	0.04	0.11	0.13	0.14	0.06	0.08
	TRA	0.00	0.00	-0.03	-0.03	-0.03	-0.03	-0.03
	STR	0.00	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03
	EI	***0.00***	***0.04***	***0.08***	***0.10***	***0.11***	***0.04***	***0.06***

Caucasus

		1992	1993	1994	1995	1996	1997	1998
Armenia	IND	0.00	0.07	-0.03	-0.04	-0.01	-0.04	-0.02
	ROE	0.00	-0.33	-0.33	-0.43	-0.39	-0.48	-0.49
	TRA	0.00	-0.02	-0.15	-0.16	-0.16	-0.17	-0.17
	STR	0.00	0.05	0.06	0.05	0.05	0.04	0.04
	EI	***0.00***	***-0.23***	***-0.44***	***-0.58***	***-0.51***	***-0.64***	***-0.64***
Azerbaijan	IND	0.00	0.26	0.30	0.20	0.14	0.10	0.04
	ROE	0.00	-0.29	-0.13	0.06	-0.04	-0.05	-0.23
	TRA	0.00	0.00	0.04	0.04	0.03	0.00	-0.01
	STR	0.00	0.00	0.02	0.01	0.02	0.02	0.04
	EI	***0.00***	***-0.03***	***0.20***	***0.31***	***0.14***	***0.07***	***-0.18***
Caucasus	IND	0.00	0.30	0.15	0.12	0.10	0.07	0.04
	ROE	0.00	-0.30	-0.18	-0.17	-0.26	-0.30	-0.38
	TRA	0.00	0.01	0.00	-0.01	-0.01	-0.02	-0.03
	STR	0.00	0.00	0.00	0.01	0.02	0.02	0.03
	EI	***0.00***	***-0.01***	***-0.03***	***-0.05***	***-0.15***	***-0.23***	***-0.34***

Central Asia

		1992	1993	1994	1995	1996	1997	1998
Kazakhstan	IND	0.00	-0.06	-0.11	-0.09	-0.10	-0.16	-0.25
	ROE	0.00	-0.01	0.05	0.03	0.01	-0.06	-0.04
	TRA	0.00	0.00	-0.02	-0.02	-0.02	-0.03	-0.03
	STR	0.00	-0.02	-0.07	-0.07	-0.07	-0.07	-0.07
	EI	***0.00***	***-0.08***	***-0.15***	***-0.17***	***-0.19***	***-0.32***	***-0.39***
Kyrgyz Republic	IND	0.00	0.08	0.27	0.25	0.33	0.28	0.16
	ROE	0.00	-0.06	0.01	0.08	0.00	-0.17	-0.06
	TRA	0.00	0.01	-0.05	-0.02	-0.02	-0.05	-0.03
	STR	0.00	-0.02	-0.07	-0.10	-0.18	-0.16	-0.09
	EI	***0.00***	***0.02***	***0.16***	***0.21***	***0.15***	***-0.05***	***0.01***
Uzbekistan	IND	0.00	0.12	0.06	0.31	0.27	0.23	0.20
	ROE	0.00	0.12	0.05	-0.08	-0.04	-0.06	-0.09
	TRA	0.00	0.00	-0.01	-0.02	-0.01	0.00	-0.01
	STR	0.00	0.03	0.04	-0.01	0.00	0.00	0.00
	EI	***0.00***	***0.26***	***0.14***	***0.22***	***0.23***	***0.19***	***0.11***
Central Asia	IND	0.00	0.01	-0.03	0.07	0.05	0.00	-0.08
	ROE	0.00	0.04	0.06	0.01	0.01	-0.04	-0.04
	TRA	0.00	0.00	-0.02	-0.02	-0.02	-0.02	-0.02
	STR	0.00	-0.02	-0.04	-0.06	-0.06	-0.06	-0.05
	EI	***0.00***	***0.04***	***-0.04***	***-0.01***	***-0.03***	***-0.13***	***-0.19***