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The impact of international trade on environmental quality: The case of transition countries

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ABSTRACT

This research presents first empirical time series evidence of the impact of international trade on environmental quality in the case of transition countries. The linkages between international trade and environmental quality are well established both theoretically and empirically in the literature. However, there exists no empirical study concerning environmental quality and international trade. Thus, our research aims at filling this gap. To this extent, fifteen transition countries are selected in order to test the impact of international trade on environmental quality. An econometric model between carbon emissions, energy use, income and trade openness was formed. This model was estimated via ARDL (Autoregressive Distributed Lag) approach to cointegration and GMM (Generalized Method of Moments) procedures. The econometric results from both of these econometric techniques support the existence of the EKC hypothesis only in three transition countries: Estonia, Turkmenistan and Uzbekistan. As for the impact of trade on environmental quality, the econometric results from both techniques vary in different transition countries. To this extent, the displacement hypothesis is validated in the case of Armenia, Estonia, Latvia, Kyrgyzstan and Russia. The paper also discusses policy implications of the empirical results, as well as offering policy recommendations.

1. Introduction

A recent study of the Intergovernmental Panel on Climate Change [37] reports that the period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere. A warming of 0.85 °C (Celsius) over the period 1880 to 2012 was recorded globally. It is also anticipated that providing that the trend in GHGs (Greenhouse Gases) emissions continues at the same pace, the global temperature will rise between 1.1 °C and 6.4 °C and the sea level will increase between 15.8 cm and 16.5 cm in 2100, which would result in catastrophic consequences in people's lives. The adverse impact of climate change on global GDP (Gross Domestic Product) economies is estimated between 5% and 20% decline if there is no immediate action to reduce GHGs, as discussed in Stern [64]. The World Resources Institute [71] reports that global GHGs emissions increased sharply from 32414 to 46049 M_tCO_2e (million metric tons of carbon dioxide equivalent) between 1990 and 2012. The amount of CO_2 (carbon dioxide) emissions constitutes around 60% of GHGs. A large part of CO_2 emissions comes from fossil energy sources that are being used as the primary energy input for economic growth. According to the International Energy Agency [35], the total primary energy consumption more than doubled between 1973 and 2013 from 6100 to 13541 Mtoe (million tons of oil equivalent).

The 2015 United Nations climate change conference in Paris was attended by 195 countries and it was the 11th meeting of the 1997 Kyoto protocol. The conference negotiated a global agreement on the reduction of emission of greenhouse gases which have been blamed for being the main cause of climate change worldwide. The agreement set a goal of limiting global warming to 1.5 °C which requires zero emissions sometime between 2030 and 2050. As compared to the Kyoto protocol, the Paris agreement did not set out any detailed timetable or country specific goals for GHGs and it will be put in force at end of 2020.

Prior to the dissolution of the Soviet Union in 1991, CO_2 emissions in its member countries were growing at an annual rate of 4.8% since 1950. The share of the Soviet Union countries' CO_2 emissions in the world increased from 12% to 16% for the same

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period, mainly due to the discovery and exploitation of natural gas resources [52]. Since the dissolution of the Soviet Union, its former member countries have been passing through a considerable transformation from socialism to a market economy. According to the World Bank [68]; former members of the Soviet Union have a tendency of a decline in the CO_2 emissions, except Kazakhstan, Turkmenistan and Armenia. The share of these former Soviet Union countries in the world CO_2 emissions decreased to 7.81% in 2010, whereas Russia composes 5.18% of the world CO_2 emissions in the same period. Despite the decline tendency, CO_2 emissions *per capita* are still high, thus according to EDGAR [17]; Russia takes fifth place in the world according to total CO2 emissions and sixth place CO_2 emissions *per capita*. In spite of these environmental poor degradation indicators in Russia, it still distances itself from the United Nations' climate protocols and conferences, which causes concerns amongst environmentalists.

We are motivated by the fact that environmental degradation and economic growth relationship in transition economies have not been researched empirically previously as far as this study is concerned. The validity of the so-called EKC (Environmental Kuznets Curve) and displacement hypotheses will be tested econometrically by utilizing two different cointegration techniques for fifteen transition countries over the period of 1991–2013. The extent of environmental degradation and its determinants provide important policy parameters for the policy makers to tackle the issues appropriately. Thus, this research presents the first empirical evidence on both hypotheses for fifteen transition countries. The empirical results indicate that the EKC hypothesis has been validated in the case of Estonia, Turkmenistan and Uzbekistan on using both econometric procedures which are adopted by this research. Concerning the displacement hypothesis, this study presents support in the case of Armenia, Estonia, Latvia, Kyrgyzstan and Russia.

The rest of the paper is organized as follows. The next section outlines the literature review on relationships between CO_2 emissions and economic growth. The third section outlines the adopted cointegration methodologies. The fourth section reports and discusses the obtained empirical results, and finally, the last section presents the conclusion.

2. A brief literature review

There have been numerous studies, both theoretical and empirical, attempting to analyze and to test the EKC hypothesis. The EKC concept provides an analytical framework to examine the relationship between environmental quality and income. The EKC hypothesis postulates an inverted U-shaped relationship between environmental quality that can be measured by different environmental indicators and economic growth. The EKC concept, named after the Kuznets curve, originally describes relations between income inequality and income level as the inverted U-shaped curve [46]. The environmental extension of the Kuznets curve took its origin from Grossman and Krueger [22] and with Shafik and Bandyopadyay [61]. Grossman and Krueger [22] examined potential environmental impacts of NAFTA (North Atlantic Free Trade Area) by estimating the EKC hypothesis using environmental indicators such as SO_2 dark matter (fine smoke) and suspended particles. Examining air quality measures in a cross-section of countries, authors found that economic growth reduces pollution problems when the *per capita* income level reaches 4000–5000 U.S. dollars.

Shafik and Bandyopadyay [61] investigated the relationships between environmental quality and economic growth at different levels of income. They found that income level has a significant effect on measures of environmental quality; however, they discovered that these relationships are not linear. Most measures of environmental quality tend to deteriorate with an increase of income level. Results of this study received a lot of attention in the literature after they were used in the World Development Report of the IBRD for 1992.

Since then, the topic of the EKC concept has attracted a lot of empirical research interest. The main idea of the EKC concept is that environmental degradation increases with the growth of income level until a certain point of income, when the environment starts to improve which generates the inverted U-shaped curve. However, empirical results of the EKC hypothesis are usually not consistent or comprehensive due to the adopted econometric methodologies or the selected time spans.

A number of surveys have been done on the EKC hypothesis, such as Lieb [50]; He [33]; Dinda [16]; Stern [66]; Payne [56]; Aslanidis [5]; Bo [10]; Kijima et al. [41] and Pastern and Figueroa [55]; that cover theoretical as well as empirical studies. One of the main purposes of studies is to find out whether the EKC concept exists and, if it exists, to find reasons for its inverted U-shape. Different reasons in the literature are discussed as driving forces for the inverted U-shaped curve. For example, one of them is the income elasticity for environmental quality [20,43–45]. As income level increases, people increase their demand for better environmental quality; many studies stress that willingness to pay for a cleaner environment rises faster than income level, in other words, income elasticity is greater than unity which illustrates a clean environment as luxury goods. Another cause is a technological reason [4,9,22,59,70], where economic growth leads to greater pollution. After a country reaches a certain level of wealth, it starts to invest in research and development, replacing obsolete technology with newer ones that lead to pollution abatement. Increasing returns to scale in pollution abatement is another widely discussed reason [4,18,51,69]. Hypothesis of increasing returns to scale in pollution abatement states that when continuous efforts for pollution reduction are undertaken the efficiency of pollution abatement rises and fewer efforts lead to larger abatement of pollution.

The Hecksher-Ohlin trade theory suggests that, under free trade, developing countries would specialize in the production of goods which available labour and abundant natural resources enables. The developed countries would specialize in human capital and manufactured capital intensive activities. Trade entails the movement of goods produced in one country to another for either consumption or further processing. This implies that pollution is generated in the production of these goods and is related to consumption in another country. Lately with greater involvement of developing countries into international trade, trade openness became one of the important discussion points for the inverted U-shaped EKC [12,13,22,34,42,47,49,61,62,65,67]; and [6]. The study of Halicioglu [27] was first to introduce empirically the trade openness variable in econometric estimations of the EKC hypothesis. Shafik and Bandyopadhyay [61] suggest that in a country that is more open to trade, less pollution will be observed. More open countries experience a higher level of competition, investing in new efficient technologies leading to pollution abatement. However, results of this study did not provide convincing evidence to validate the EKC hypothesis. Suri and Chapman [67] stressed the importance of considering trade in both energy-intensive and in non-energy-intensive goods. For example, such non-energy-intensive manufacture of automobiles requires high-pollution intensive inputs. They found that industrialized countries manage to reduce the level of pollution by exporting highly energy intensive goods, while developing countries experience mounting pollution due to their growing exports of energy intensive products. This hypothesis received wide interest in the literature and is known as *displacement hypothesis* or *pollution haven hypothesis* [2,11,13,36,38,39,53,65,67,72]. In the frame of global liberalization, trade barriers tend to decrease and to disappear so international trade becomes easier. Developed countries that enforce strict environmental regulations transfer pollution-intensive production to countries with weaker environmental regulations. As a result, less developed countries become net importers of pollution-intensive goods, while developed countries become net exporters. Migration of polluted productions to less developed countries generates displacement of environmental effects from rich to poor countries.

3. Model and econometric methodology

3.1. Model

Following the previous studies of Halicioglu [27]; Kearsley and Riddel [38] and Pasten and Figueroa [55]; the impact of trade on environmental degradation is empirically formulated as follows:

$$c_t = a_0 + a_1 e_t + a_2 y_t + a_3 y_t^2 + a_4 f_t + \varepsilon_t \tag{1}$$

where c_t is CO_2 emissions *per capita*, e_t is commercial energy use *per capita*, y_t is *per capita* real income, y_t^2 is square of *per capita* real income, f_t is trade openness ratio which is used as a proxy for foreign trade, and ε_t is the regression error term. The lower case letters in equation (1) demonstrate that all variables are in their natural logarithms.

The sign expectations for the parameters in equation (1) are as follows: $a_1 > 0$, $a_2 > 0$, $a_3 < 0$, and$a_4 > 0$ or $a_4 < 0$. It is clear that one expects a_1 to be positive because a higher level of energy consumption should result in greater economic activity and stimulate CO_2 emissions. Under the EKC hypothesis, the sign of a_2 is expected to be positive whereas a negative sign is expected for a_3. If one finds that a_3 is statistically insignificant, it indicates a monotonic increase in the relationship between *per capita* CO_2 emissions and *per capita* income. The expected sign of a_4 is mixed depending on the level of economic development stage of a country. According to Grossman and Krueger [21]; developed countries tend to import less pollution-intensive goods and export pollution-intensive goods to those countries with less-restrictive environmental laws. However, this sign expectation is reversed in the case of developing countries, as they tend to have dirty industries with a heavy share of pollutants. Moreover, environmental concerns and the related laws in these countries are relaxed due to production cost related issues. Equation (1) can also be estimated using disaggregated data by employing different measurements of greenhouse gases or industries which are discussed in detail in Kearsley and Riddel [38] and Pasten and Figueroa [55].

3.1.1. Cointegration methodology of ARDL[1]

A single cointegration approach, known as ARDL (autoregressive-distributed lag) of Pesaran et al. [57]; has become popular amongst researchers. Pesaran et al.'s cointegration approach, also known as bounds testing, has certain econometric advantages in comparison to other single cointegration procedures. The first important advantage of this methodology is that endogeneity problems and the inability to test hypotheses on the estimated coefficients in the long-run associated with the Engle-Granger method are avoided. Moreover, with this approach, the long-run and short-run parameters of the model in question are estimated simultaneously. Furthermore, the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration, as argued in Narayan [54].

An ARDL representation of equation (1) is formulated as follows:

$$\begin{aligned}\Delta c_t = {} & b_0 + \sum_{i=1}^{n1} b_{1i}\Delta c_{t-i} + \sum_{i=0}^{n2} b_{2i}\Delta e_{t-i} + \sum_{i=0}^{n3} b_{3i}\Delta y_{t-i} \\ & + \sum_{i=0}^{n4} b_4 \Delta y_{t-i}^2 + \sum_{i=0}^{n5} b_5 f_t + b_6 c_{t-1} + b_7 e_{t-1} + b_8 y_{t-1} \\ & + b_9 y_{t-1}^2 + b_{10} f_{t-1} + v_t\end{aligned} \tag{2}$$

The bounds testing procedure is based on the Fisher (F) or Wald-statistics (W) and is the first stage of the ARDL cointegration method. Accordingly, a joint significance test that implies no cointegration hypothesis, ($H_0 b_6 = b_7 = b_8 = b_9 = b_{10} = 0$), against the alternative hypothesis, (H_1: at least one of b_6 to b_{10} is different from zero) should be performed for equation (2). The F-test used for this procedure has a non-standard distribution. Thus, Pesaran et al. [57] compute two sets of critical values for a given significance level with and without a time trend. One set assumes that all variables are $I(0)$ and the other set assumes they are all $I(1)$. If the computed F-statistic exceeds the upper critical bounds value, then the H_0 is rejected. If the F-statistic falls into the bounds then the test becomes inconclusive. Lastly, if the F-statistic is below the lower critical bounds value, it implies no cointegration.

Once a long-run relationship has been established, equation (2) is estimated using an appropriate lag selection criterion.

A general error correction model of equation (2) is formulated as follows:

$$\begin{aligned}\Delta c_t = {} & c_0 + \sum_{i=1}^{n1} c_{1i}\Delta c_{t-i} + \sum_{i=0}^{n2} c_{2i}\Delta e_{t-i} + \sum_{i=0}^{n3} c_{3i}\Delta y_{t-i} \\ & + \sum_{i=0}^{n4} c_{4i}\Delta y_{t-i}^2 + \sum_{i=0}^{n5} c_{5i}\Delta f_{t-i} + \lambda EC_{t-1} + \mu_t\end{aligned} \tag{3}$$

where λ is the speed of adjustment parameter and EC_{t-1} is the residuals that are obtained from the estimated cointegration model of equation (1).

3.1.2. Cointegration methodology of GMM[2]

The ARDL bounds test of cointegration is complemented by GMM (Generalized Method of Moments) methodology to provide a sensitivity check on the results. The GMM represents instrumental variables estimation and firstly was introduced by Hansen [31] in his seminal work. One of the important advantages of the GMM is that many estimators like ordinary least squares and instrumental variables are considered as special cases, making the GMM flexible in use. The orthogonality conditions are used in the GMM to allow the weighting matrix to account for serial correlation and heteroskedasticity of unknown form. Avoidance of heteroskedasticity and autocorrelation is another important advantage of the GMM. Hansen [31] developed the GMM primarily having time series applications in mind; therefore, this estimation framework is relatively advantageous for time series data, as discussed in Wooldridge [72]. Another advantage of the GMM for time series is that it does not require making complete specification of the probability distribution of data, only a partial specification of the model is necessary. The GMM approach can be represented by the following framework. Equation (1) can be rewritten in the

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[1] This section heavily relies on [3,27] and [28,1,15]; and [23–26].

[2] See more on this technique [40].

following simple form:

$$z_t = x_t'\beta_0 + \varepsilon_t \tag{4}$$

where z_t corresponds to the dependent variable CO_2 emissions *per capita*, x'_t is an *Lx1* vector of explanatory variables and which correspond to four variables of the model (1), which are commercial energy use *per capita*, *per capita* real income, *per capita* real income squared and trade openness ratio, with the regression error term ε_t. The key moment condition in estimating β coefficients is:

$$E\left[\left(z_t - x_t^{'}\beta_0\right)x_t\right] = E[\varepsilon_t x_t] = 0 \tag{5}$$

which means that x'_t may not be predetermined with respect to the regression error term ε_t. The GMM is based on the instrumental variables estimations; therefore, it is assumed that v_t is an *Kx1* vector of instrumental variables that are partially or fully generated from x_t. Set of non-constant elements (z_t, x_t, v_t) form the vector u_t which is deemed to be stationary and is generated by stochastic process. The important condition for β_0 coefficients estimation is that number of instrumental variables, *K*, has to be more or equal to number of explanatory variables, *L*. The instrumental variables are supposed to satisfy the following orthogonality conditions:

$$E[f_t(u_t, \beta_0)] = E[v_t\varepsilon_t] = E\left[v_t\left(z_t - x_t^{'}\beta_0\right)\right] \tag{6}$$

The GMM estimator of β coefficients is generated on the basis of the orthogonality condition (6) and can be expressed in the following form:

$$\widehat{\beta}\left(\widehat{U}\right) = arg\min_{\beta} W\left(\beta, \widehat{U}\right) \tag{7}$$

where $\widehat{U}$ is a positive definite symmetric matrix with *KxK* dimension, and $W(\beta, \widehat{U})$ is defined by the following expression:

$$W\left(\beta, \widehat{U}\right) = nf_n(\beta)^{'}\widehat{U}f_n(\beta) = n(S_{vz} - S_{vx}\beta)'\widehat{U}\ (S_{vz} - S_{vx}\beta) \tag{8}$$

where S_{vz} and S_{vx} are defined as follows:

$$S_{vz} = n^{-1}\sum_{t=1}^{n} v_t z_t \tag{9}$$

$$S_{vx} = n^{-1}\sum_{t=1}^{n} v_t x_t' \tag{10}$$

For more detailed and comprehensive interpretation of the GMM methodology, see Hamilton [30]; Hayashi [32]; Davidson and MacKinnon [14] and Hall [29].

3.2. Unit roots

The ARDL approach to cointegration requires that the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, or fractionally integrated. Similarly, the GMM estimation framework was considered for strictly stationary data. It is a common practice that different unit root tests are employed in order to achieve robust results. To this extent, the following unit root tests are, by and large, employed. Dickey and Fuller [60] ADF (Augmented Dickey-Fuller) unit root tests, the Elliott et al. [19] DF-GLS unit root tests, the Phillips and Perron [58] PP unit root test and finally Kwiatkowski et al. [48] KPSS unit root tests. The ADF test constructs a parametric correction for higher-order correlation. Both the AIC (Akaike Information Criterion) and SBC (Schwartz Bayesian Criterion) are used to select appropriate lag length for the ADF tests to remove any serial correlation in the residuals. The simple modification of the ADF test is proposed in the DF-GLS test, where data are de-trended to maximize power. The PP test corrects for the correlation and heteroskedasticity in the residuals, by nonparametric modification of the test statistics. Kwiatkowski et al. [48] argued that the time series for which the unit root hypothesis is not rejected do not necessarily have a unit root. Arguing that some unit root tests may have low power, they proposed an alternative test. The null hypothesis of the KPSS test is stationarity of the series with an alternative hypothesis of a unit root existence. It differs from unit root tests described above where the null hypothesis is the non-stationarity of series.

4. Empirical results

4.1. Unit root tests

Annual data over the period 1991–2013 were used to estimate equation (1) by the ARDL approach to cointegration and the GMM procedures. Data definition and sources of data are cited in the Appendix. The appendix also includes the figures of variables for 15 countries that were used in econometric studies. (See Figs. 1–4).

The time series properties of the variables in equation (1) are checked through the ADF, DF-GLS and PP tests. The results are presented in Table 1. At least one test out of four provided evidence of stationarity in series. Therefore, based on the results of the alternative unit root test, we can conclude that all the series are generated by a stationary process and none of them are above the order of integration, $I(1)$.

4.2. Cointegration tests and the ARDL procedure results

In order to test the existence of a long-run cointegrating relationship amongst the variables of equation (1), a two-step procedure to estimate the ARDL representation model was carried out. First, the selection of the optimal lag length on the first-differenced variables in equation (2), unrestricted VAR (Vector Auto Regression) was employed by means of Akaike Information Criterion. The results suggest the optimal lag length as 2, but this stage of the results is not presented here to conserve space and for brevity. Second, a bound F-test was applied to equation (2) in order to determine whether the dependent and independent variables are cointegrated. The results of the bounds F-testing are reported in Table 2. It can be seen from Table 2 that the computed F statistics are above the upper bound values in the case of only three countries, namely Estonia, Turkmenistan and Uzbekistan, thus implying cointegration relation.

4.3. Alternative evidence of cointegration

The pre-testing stage of the ARDL approach to cointegration is rather sensitive to the selected lag lengths in equation (2), as proven by Bahmani-Oskooee and Goswami [8]. Therefore, the results at this stage should be treated cautiously. In order to eliminate a possible wrong decision at this stage, Bahmani-Oskooee and Ardalani [7] recommend using an alternative evidence of cointegration which is explained briefly as follows: if the lagged linear combination of all variables in equation (2) is substituted by EC_{t-1} as expressed in equation (3), then a negative and significant coefficient of EC_{t-1} in equation (3) is considered to reflect cointegration among the variables as well as support for the short-run adjustment toward the long-run.

Table 1
Unit root tests.

Country	ADF[a]	DF-GLS[a]	PP[a]	KPSS[b]
Panel A:	*c*			
Armenia	-3.03^{**}	-2.20^{**}	-3.14^{**}	0.37
Azerbaijan	-3.06^{**}	-2.12^{**}	-2.72	0.18
Belarus	-3.87^{*}	-2.28^{**}	-3.38^{**}	0.19
Georgia	-5.95^{*}	-2.10^{**}	-5.15^{*}	0.23
Estonia	-3.03^{**}	-2.17^{**}	-3.03	0.21
Kazakhstan	-2.23	-3.06^{*}	-1.76	0.22
Kyrgyzstan	-10.28^{*}	-2.28^{**}	-10.28^{*}	0.38
Latvia	-4.81^{*}	-1.78	-5.04^{*}	0.38
Lithuania	-3.22^{**}	-11.06^{*}	-3.31^{**}	0.28
Moldavia	-4.29^{*}	-1.17	-5.49^{*}	0.36
Russia	-4.39^{*}	-2.33^{**}	-3.93^{*}	0.18
Tajikistan	-11.14^{*}	0.16	-33.48^{*}	0.43
Turkmenistan	-1.04	1.07	0.79	0.34
Ukraine	-6.76^{*}	-1.92	-14.99^{*}	0.39
Uzbekistan	-2.69^{**}	-1.51	-2.66	0.38
Panel B:	*e*			
Armenia	-4.07^{*}	-2.06^{**}	-3.67^{**}	0.19
Azerbaijan	-5.56^{*}	-1.92	-5.74^{*}	0.45
Belarus	-3.66^{*}	-4.93^{*}	-3.17^{**}	0.16
Georgia	-3.64^{*}	-2.39^{**}	-3.64^{**}	0.32
Estonia	-4.89^{*}	-2.34^{**}	-4.60^{*}	0.19
Kazakhstan	-2.24	-2.55^{**}	-1.16	0.25
Kyrgyzstan	-5.06^{*}	-2.04^{**}	-5.06^{*}	0.34
Latvia	-2.91^{**}	-14.07^{*}	-2.94	0.16
Lithuania	-5.76^{*}	-2.46^{**}	-5.25^{*}	0.13
Moldavia	-2.15	-1.79	-4.19^{*}	0.31
Russia	-2.19	-2.23^{**}	-2.31	0.23
Tajikistan	-3.50^{**}	-1.97^{**}	-7.47^{*}	0.43
Turkmenistan	0.22	-12.59^{*}	-1.11	0.40
Ukraine	-4.08^{*}	1.63	-4.55^{*}	0.44
Uzbekistan	-1.66	-1.22	-1.66	0.37
Panel C:	*y*			
Armenia	-1.42	-2.19^{**}	-0.15	0.41
Azerbaijan	-1.96	-2.39^{**}	-0.58	0.35
Belarus	-3.32^{**}	-3.44^{*}	0.30	0.40
Georgia	-0.91	-3.16^{*}	-1.36	0.39
Estonia	-1.09	-1.51	-0.38	0.42
Kazakhstan	-1.78	-2.20^{**}	0.16	0.39
Kyrgyzstan	-1.13	-0.99	-1.58	0.37
Latvia	-0.77	-1.43	-0.23	0.41
Lithuania	0.21	-3.64^{*}	-0.24	0.39
Moldavia	-1.47	-1.99^{**}	-2.10	0.26
Russia	-4.77^{*}	-1.04	-0.59	0.49^{**}
Tajikistan	-2.61	-3.58^{*}	-2.19	0.24
Turkmenistan	0.99	-2.13^{**}	0.43	0.48^{**}
Ukraine	-1.80	-2.48^{**}	-1.65	0.27
Uzbekistan	1.02	-2.76^{*}	0.93	0.39
Panel D:	*f*			
Armenia	-2.13	-1.66	-1.70	0.37
Azerbaijan	-3.58^{*}	-3.73^{*}	-2.86	0.14
Belarus	-5.31^{*}	-0.95	-5.05^{*}	0.27
Georgia	-2.38	-2.61^{**}	-2.55	0.18
Estonia	-5.46^{*}	-1.98^{**}	-4.87^{*}	0.62^{**}
Kazakhstan	-3.39^{**}	-3.23^{*}	-3.45^{**}	0.15
Kyrgyzstan	-0.80	-0.60	-0.80	0.44
Latvia	-5.53^{*}	-3.47^{*}	-5.28^{*}	0.22
Lithuania	-3.47^{**}	-2.59^{**}	-3.51^{**}	0.52^{**}
Moldavia	-2.43	-1.79	-3.31^{**}	0.42
Russia	-7.36^{*}	-3.72^{*}	-6.93^{*}	0.18
Tajikistan	-3.02^{**}	-2.28^{**}	-2.27	0.13
Turkmenistan	-4.41^{*}	-8.18^{*}	-3.87^{*}	0.13
Ukraine	-5.01^{*}	-1.52	-4.31^{*}	0.34
Uzbekistan	-3.13^{**}	-3.46^{*}	-2.85	0.18

Notes: In the KPSS test critical values are used from Ref. [48]. (a) Null of non-stationarity (unit root), (b) Null of stationarity. * and ** denote the rejection of the null hypothesis at the 1% and 5% respectively. In unit root tests for time series: the ADF, the DF-GLS and the PP tests critical values are used from MacKinnon (1996) one-sided p-values.

Table 2
The results of F tests for cointegration.

The assumed long-run relationship: $F\ (c \mid e,\ y,\ y^2, f)$					
Countries	F-statistic	95% LB	95% UB	90% LB	90% UB
Armenia	n.a.				
Azerbaijan	n.a.				
Belarus	n.a.				
Georgia	n.a.				
Estonia	**9.54**	3.741	5.232	2.969	4.284
Kazakhstan	n.a.				
Kyrgyzstan	n.a.				
Latvia	1.85	3.741	5.232	2.969	4.284
Lithuania	n.a.				
Moldavia	n.a.				
Russia	0.809	3.610	5.078	2.909	4.203
Tajikistan	n.a.				
Turkmenistan	**9.873**	3.741	5.232	2.969	4.284
Ukraine	n.a.				
Uzbekistan	**5.420**	3.741	5.232	2.969	4.284

If the test statistic lies between the bounds, the test is inconclusive. If it is above the upper bound (UB), the null hypothesis of no level effect is rejected. If it is below the lower bound (LB), the null hypothesis of no level effect cannot be rejected. Wald test statistics are not presented here for brevity but they reveal identical results.

Table 3 provides the short-run summary results of the ARDL approach to cointegration; the econometric diagnostics of the estimations are rather satisfactory indicating that the estimated models are free from econometric problems. Thus, statistical inference from these results is validated. Initially, considering the alternative evidence of cointegration on the basis of statistically significant EC_{t-1} term,[3] it is noted that the number of countries in the econometric analyses increases from three to five. In regards to short-term dynamics, the speed of adjustment is highest in Estonia which is closely followed by Latvia.

Table 4 suggests that the EKC hypothesis is validated in the case of only five transition countries out of fifteen. As for the main research concern of this study, the impact of foreign trade on environmental quality in the long-run is statistically significant in the case of Latvia, Russia and Turkmenistan. Within these countries, the impact of foreign trade on environmental quality is positive in the case of Turkmenistan: the environmental quality in Turkmenistan suffers a detrimental effect of international trade in the long-run. In the case of Russia and Latvia, the displacement hypothesis is validated since both countries appear to be exporting CO_2 emissions to other countries which contradict *priori* expectations. Magnitude of the trade openness coefficient in absolute value is substantially higher in Latvia than Russia, suggesting that the economic development level in Latvia is considerably higher than Russia. Table 4 confirms indirectly that the development stages of the former Soviet Union that the countries in the east of the Union are relatively less developed than the countries in the west.

4.4. GMM estimations

Table 5 presents the results of time series estimations employing GMM approach. The GMM estimations for all countries pass the ST (Sargan Test), the *p* values of which are presented in the last column of Table 5. The GMM estimations are econometrically sound and precise as far as the summary diagnostic test results are concerned.

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[3] We note that the speed of adjustment to be negative and less than one. Therefore, a coefficient of greater than one in absolute value such as 2.24 in Uzbekistan suggests that 0.56% of the adjustment takes place in about six months since the data are annual.

Table 3
ARDL approach to cointegration summary short-run results.

Countries	EC_{t-1}	Error-correction model test diagnostics				Short-run model diagnostic test statistics			
		$\overline{R}^2$	DW-statistic	F-statistic	RSS	χ^2_{SC}	χ^2_{FF}	χ^2_{N}	χ^2_{H}
Estonia	−2.00	0.99	2.55	324.3*		2.79	0.36	0.42	2.89
	(5.83)*				0.01				
Latvia	−1.96	0.65	2.39	6.20*		5.45	0.25	0.88	0.49
	(2.56)*				0.01				
Russia	−0.73	0.88	2.84	36.63*		0.26	0.15	1.37	0.37
	(5.34)*				0.004				
Turkmenistan	−1.45	0.85	1.92	20.63*		0.02	0.02	0.29	1.71
	(6.22)*				0.01				
Uzbekistan	−2.24	0.88	1.66	20.37*		0.95	7.62	1.29	0.27
	(4.46)*				0.003				

RSS stands for Residuals Sums of Squares. χ^2_{SC}, χ^2_{FF}, χ^2_{N}, and χ^2_{H} are Lagrange multiplier statistics for tests of residual correlation, functional form mis-specification, non-normal errors and heteroskedasticity, respectively. These statistics are distributed as chi-squared variates with degrees of freedom in parentheses. The critical values for $\chi^2(1) = 3.84$ and $\chi^2(2) = 5.99$ at 5% significance level.

Table 4
ARDL approach to cointegration summary long-run results.

Countries	Order of ARDL[a]	Estimated coefficients				
		a_0	a_1	a_2	a_3	a_4
Estonia	AIC (2,2,2,2,1)	−16.09	1.13	2.04	−0.11	−0.02
		(4.19)*	(23.9)*	(2.59)**	(2.60)**	(1.53)
Latvia	$\overline{R}^2$(1,2,2,0,2)	−20.17	2.80	1.44	−0.11	−0.89
		(1.19)	(7.74)*	(0.49)	(0.63)	(4.11)*
Russia	HQC (1,0,0,1,1)	−15.39	1.17	2.05	−0.12	−0.05
		(1.86)***	(11.9)*	(1.01)	(1.09)	(1.87)***
Turkmenistan	AIC (1,2,0,1,1)	−14.69	1.21	1.72	−0.12	0.16
		(3.03)*	(5.76)*	(1.11)	(1.23)	(2.20)**
Uzbekistan	AIC (2,2,0,2,1)	−15.52	0.99	2.88	−0.21	0.01
		(5.61)*	(10.73)*	(2.77)**	(2.66)**	(0.87)

*, ** and *** indicate, 1%, 5% and 10% significance levels, respectively. The numbers in parentheses represents the t-ratios in absolute values.

[a] $\overline{R}^2$, AIC, SBC, and HQC criteria are utilized appropriately to select the order of ARDL. The order of optimum lags is based on the specified ARDL model.

Table 5 presents that the EKC hypothesis is being supported in the case of Armenia, Estonia, Kyrgyzstan, Turkmenistan and Uzbekistan. The econometric results in all of these countries also demonstrate that there exists a statistically significant, negative association between environmental quality and trade openness, which validates the displacement hypothesis. Whilst the ARDL approach to cointegration and GMM procedures suggest that the EKC hypothesis is valid in the case of Estonia, Turkmenistan and Uzbekistan, the displacement hypothesis is not being supported in the same countries by the combination of two different cointegration techniques.

The GMM procedure tends to validate both the EKC and displacement hypotheses for more transition countries than the ARDL approach to the cointegration, since the first procedure is able to use more instruments if needed; however, the GMM procedure lacks the short run dynamics that the ARDL method presents which allows more comprehensive econometric analysis for the estimated parameters.

Considering the fact the econometric study of this study is based on relatively small samples with only 23 annual observations, the inferences are subject to small sample biasness to a certain extent.

5. Conclusions

This research has attempted to analyze empirically, for the first time, the relationship between the environmental quality and trade openness in the case of fifteen transition countries. Our empirical results are obtained from the ARDL approach to cointegration and GMM procedures which suggest robustly that the EKC hypothesis is validated in the case of Estonia, Turkmenistan and Uzbekistan. There also exists some support of the EKC hypothesis in the case of Armenia, Kyrgyzstan, Latvia and Russia. Within these countries, the displacement hypothesis is also partially supported in the case of Armenia, Estonia, Latvia, Kyrgyzstan and Russia. Broadly speaking, the impact of trade on environmental quality in the breakaway countries of the Soviet Union varies according to their development level terms.

Countries which face detrimental effects of trade on environmental quality should design and implement trade policies so that the CO_2 emissions embedded within imported goods should be minimized. To this extent, in the short-run, strict border controls including CO_2 and related emission reports of imported and transported goods might alleviate the problem. The importers and manufacturers may also be given special production incentives to replace the CO_2 contaminated goods with the domestically produced CO_2 free goods in the long-run. The global carbon taxes on CO_2 emissions from transporting goods may increase global and implementing regions' welfare; however, it may have detrimental effects on less developed countries, as discussed in Shapiro [63]. Designing the environmental policies to combat the adverse effects of international trade also requires good policy coordination between trading partners. However, it is also a difficult task to implement the appropriate trading policies between the trading countries due to their different trade objectives. Regional trade agreements appear to be partially alleviating the disagreements amongst the trading partners, however.

Table 5
GMM results.

Countries	a_0	Estimated a_1	Coefficients a_2	a_3	a_4	NI	ST
Armenia	−21.08 (3.80)*	1.46 (6.27)*	4.52 (2.88)**	−0.33 (2.98)**	−0.65 (2.78)**	5	0.33
Azerbaijan	163.78 (3.74)*	3.29 (3.54)*	−53.01 (3.71)*	3.68 (3.82)*	1.45 (2.06)***	8	0.49
Belarus	−255.53 (8.56)*	0.08 (0.11)	60.35 (8.89)*	−3.59 (8.52)*	1.59 (7.77)*	12	0.33
Georgia	−90.93 (1.71)	0.95 (1.91)***	24.27 (1.69)	−1.58 (1.62)	−1.53 (2.76)**	6	0.20
Estonia	−217.97 (4.89)*	13.77 (34.43)*	24.58 (2.60)**	−1.37 (2.57)**	1.38 (4.05)*	4	0.49
Kazakhstan	33.37 (0.34)	6.74 (6.71)*	−23.53 (0.96)	1.63 (1.06)	1.62 (2.29)**	4	0.40
Kyrgyzstan	−50.95 (2.55)**	0.97 (4.43)*	14.77 (2.36)**	−1.23 (2.34)**	0.32 (2.03)***	4	0.42
Latvia	−42.49 (0.74)	2.39 (1.51)	6.77 (0.46)	−0.36 (0.44)	−0.89 (2.35)**	9	0.42
Lithuania	255.22 (6.81)*	1.39 (4.14)*	−60.27 (7.45)*	3.43 (7.41)*	0.57 (1.95)***	5	0.28
Moldavia	19.11 (1.65)	2.83 (12.94)*	−10.19 (2.89)*	0.76 (2.84)**	−0.58 (5.69)*	7	0.49
Russia	16.42 (1.23)	7.67 (12.76)*	−16.15 (6.50)*	0.96 (6.19)*	−0.44 (6.11)*	5	0.35
Tajikistan	8.16 (2.25)**	0.29 (2.36)**	−3.23 (2.64)**	0.28 (2.59)**	−0.05 (1.86)***	5	0.37
Turkmenistan	−100.67 (3.79)*	6.97 (8.68)*	12.25 (2.16)**	−0.78 (2.11)**	0.98 (1.82)***	4	0.48
Ukraine	−90.26 (1.09)	8.33 (4.59)*	10.69 (0.42)	−0.76 (0.44)	−1.41 (2.20)**	3	0.17
Uzbekistan	−52.63 (7.75)*	4.63 (17.72)*	6.52 (2.53)*	−0.49 (2.41)**	0.21 (3.02)*	4	0.43

*, ** and *** indicate, 1%, 5% and 10% significance levels, respectively. The numbers in parentheses represents the t-ratios in absolute values. NI refers to the for number of instruments; and ST (Sargan p values) are reported in last two columns.

The United Nations' climate protocols and conferences are positive, efficient international collaborations, which aim to reduce CO_2 emissions world-wide. Therefore, the transition countries should be a part of these international policies and make a full commitment to them. The Paris agreement on climate change is another important step forward in the right direction which brought around 195 countries to policy formulating discussions including those fifteen transition countries included in this study. In spite of disagreements on how to deal with to the issue of GHGs, there is a world-wide awareness that the global climate change is a problem for the entire world and transition countries are not exempted from it. Due to their isolated political and economic systems, transition countries faced the environmental problems more severely than those countries in the capitalist economic systems. It is high time that transition countries face the reality of environmental degradation and cooperate with the countries and international organizations which have been dealing with this issue since the 1990s.

We note that our econometric results are based on short-data span due to the fact that the Soviet Union started to break in the 1990s and hence a small sample bias is not avoidable in this study. We hope that as time goes by, the robustness of the results will be tested with longer data span and more advanced econometric techniques.

Appendix

Data definition and sources

All data are collected from International Financial Statistics of the IMF (International Monetary Fund) and World Development Indicators of the WB (World Bank).

c is CO_2 emissions measured in metric tons *per capita*, in logarithm. Source: WB.
e is commercial energy use measured in kg of oil equivalent *per capita*, in logarithm. Source: WB.
y is *per capita* real gross domestic product in U.S. dollars, in logarithm. Base year is 2005 = 100. Source: IMF.
y^2 is square of *per capita* real gross national income. Source: Own calculation.
f is openness ratio measured as the summation of real exports and imports over real gross national product in U.S. dollars, in logarithm. Base year is 2005 = 100. Source: IMF.

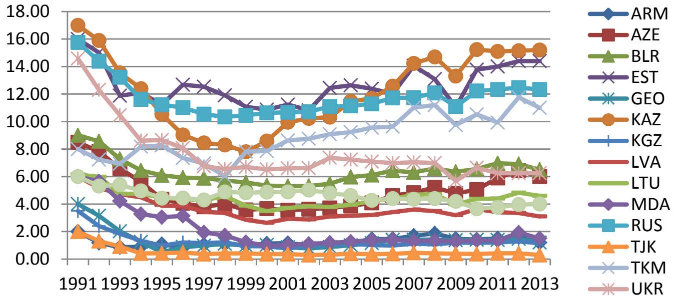

Fig. 1. CO_2 emissions *per capita* (c).

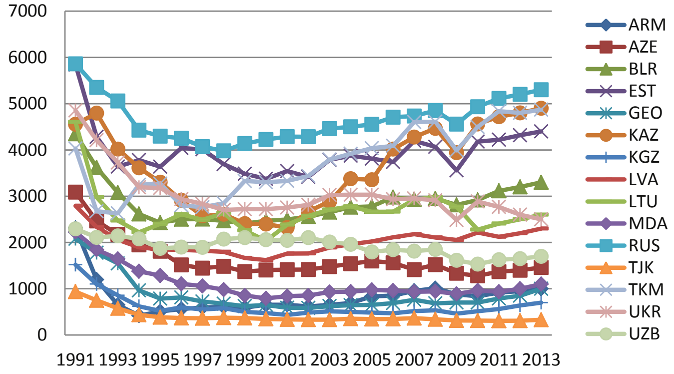

Fig. 2. Commercial energy use *per capita* (e). 2

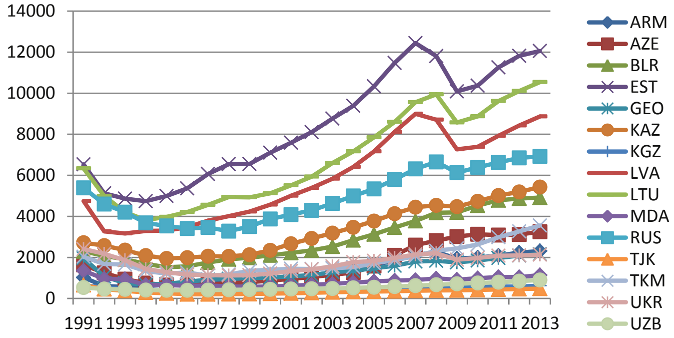

Fig. 3. Per capita real income (y).3

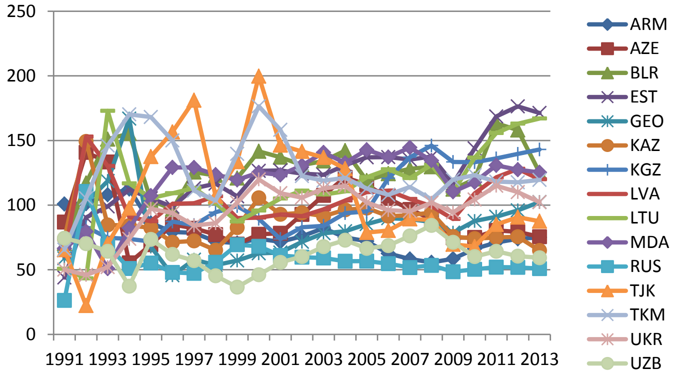

Fig. 4. Trade openness ratio (f). 4

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