Center for
Energy and
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Economic
Studies

Olga Podkorytova

Yulia Raskina

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Working paper CE3S-04/14

St. Petersburg
2014

УДК 330.35
ББК 65.012.2
П44

European University at St. Petersburg
Department of Economics

Université Catholique de Louvain
Center for Operations Research and Econometrics

Center for Energy and Environmental Economic Studies

Podkorytova O., Raskina Y.
П44 Trade and the Environmental Kuznets Curve: A Panel Data Approach / Olga Podkorytova, Yulia Raskina: CEEES paper CE3S-04/14; Center for Energy and Environmental Economic Studies. — St. Petersburg: EUSP, 2014. — 10 p.

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Olga Podkorytova, European University at St. Petersburg, 3 Gagarinskaya Str.,
St. Petersburg, 191187, Russia.
Faculty of Economics, St. Petersburg State University, 62 Tchaikovsky Str.
St. Petersburg, 191123, Russia.
E-mail: opodkorytova@eu.spb.ru

Yulia Raskina, European University at St.Petersburg, 3 Gagarinskaya Str.,
St.Petersburg, 191187, Russia.
E-mail: raskina@eu.spb.ru

Издание осуществлено за счет средств проекта создания специализации по природным ресурсам и экономике энергетики «ЭксонМобил»

Trade and the environmental Kuznets curve: a panel data approach

Podkorytova Olga[a,b]
Raskina Yulia[a]
[a]European University at St.Petersburg
[b]Saint-Petersburg State University

Abstract

Environmental Kuznets curve (EKC) describes the relationship between the economic growth and the environmental degradation. Some researchers assume that this nexus may be influenced by international trade. In this paper we estimated EKC for carbon dioxide emissions using panel data for 15 countries of the former Soviet Union spanning the period 1990-2011. We revealed positive dependence of the carbon dioxide emissions on export. We also found that foreign direct investment does not affect air pollution.

Keywords: environmental Kuznets curve, former USSR, carbon emissions, panel data, trade turnover

Introduction

The fact that environmental pollution is associated with economic development is undeniable. Nevertheless questions about the form of this dependence and the factors, that can influence it, remain open. Relevant studies were initiated in the early 70s of the 20th century. The most popular issue at present is the concept of the environmental Kuznets curve. This curve is named after Kuznets (1955), who presumed that economic inequality increases in parallel with per capita income to some threshold (turning point), after which it begins to decrease. The EKC was popularized by works of Grossman and Krueger (1991), Panayotou (1993) and Shafik (1994) in the early 1990s.

This concept assumes that pollution–growth nexus has inverted U-shape (or N-shape). The point is that at early stages of their development economy and industry lead to increased pollution. When a specific income "turning point" is reached, population initiates ~~to~~ demand for environmental goods. The latter stimulates the growth of cleaner technologies, so pollution starts to decline. Suchwise we get inverted U-shape curve.

Some authors assert that if the benefits of the technologies that exist at the moment are exhausted in the process of time, then further growth could again lead to increased pollutions (and we get second turning point and N-shape curve).

These turning points depend on numerous factors; several researchers assume that this pattern may be influenced by international trade. On the one hand, trade liberalization may influence environment in different ways. Systematic analysis of Grossman and Krueger (1991) distinguished three effects in impact of trade liberalization on pollution: the scale effect (market enlargement), the technique effect (greater access to clean technologies) and the composition effect (shift from manufacturing sector towards services sector). On the other hand, developed countries can transfer pollution intensive industries to developing countries, hence growing production and export of such goods from developing countries will lead to increased pollution in these countries (pollution haven hypothesis (Dinda, 2004)) . This causes the ascending branch of EKC to become longer and shifts turning point to the right.

We focus on the environmental pollution due to CO_2 emissions from fuel combustion, since these emissions are main anthropogenic factors increasing the greenhouse effect.

The Former Soviet Union[1] presents a particular interest to study for several reasons. First, some of these countries have already shifted from a command economy to market economy while others are undergoing this process. Processes of rapid liberalization occurred in different fields, including international trade. According to International Energy Agency (IEA, 2013), CO_2 emissions by the FSU reduced 1.5 times between 1990 and 2010, while global emissions increased by a factor of 1.5. Second, some countries joined the EU, which implies an opportunity to adopt cleaner technologies. It is possible to explain CO2 reductions at the beginning of the reviewed period by a significant fall in GDP. However, at the end of the period 11 of the 15 countries have GDP which significantly exceeds the initial level. Therefore, carbon intensity of GDP generally was decreasing in the FSU though GDP was growing. Finally, some FSU countries specialize in production and sale of energy resources, and, traditionally, this production is quite a strong source of pollution.

To the best of our knowledge, there is no study that has addressed the relationship between environmental pollution, energy consumption and trade openness for the case of the FSU. We want to answer the following questions in this paper:

- What form has environmental Kuznets curve for the FSU countries?
- Does trade liberalization lead to higher environmental sustainability?

[1] Hereinafter referred to as FSU countries

Methodology and Related studies

Literature on EKC is vast and varied. A wide array of studies uses country specific and cross-country data, time series and panel approaches, air and water pollution records, etc. If we confine our study to air pollution case, then commonly used measures of pollution are local indicators (such as sulphur dioxide SO_2, carbon monoxide CO, nitrous oxide N_2O) and global ones (carbon dioxide CO_2). Kaika and Zervas (2003) had provided a comprehensive review of EKC causes, evolution, testing methodology and the literature in the CO_2 emissions case. So not to inflate our paper volume we refer only to the key concepts. To find the EKC one needs to estimate regression

$$P_i = \alpha + \beta_1 GDPPC_i + \beta_2 GDPPC_i^2 + \beta_3 GDPPC_i^3 + controlling\ \mathrm{var}iables + \varepsilon_i, \qquad (1)$$

where P is pollution, $GDPPC$ is GDP per capita , i is a country index, ε is the error term. In the literature there are three basic variants for the dependent variable: per capita emissions, total emissions and emission intensity. If $\beta_2 = \beta_3 = 0,$ we have monotonous rise $(\beta_1 > 0)$ or decline $(\beta_1 < 0)$. If $\beta_2 < 0, \beta_3 = 0,$ we get so called inverted U-shape, which is symmetric with respect to the turning point $-\frac{\beta_1}{2\beta_2}$. If $\beta_1 > 0, \beta_2 < 0, \beta_3 > 0$, we observe so called N-shape (rising, falling, rising). In this case EKC does not have to be symmetric, so rise and fall may have different speeds. It is possible to estimate (1) in levels or in logarithms.

Numerous empirical results suggest that income, energy consumption and trade are significant factors. Cole (2004) revealed negative or insignificant effect on different types of emissions using North–South trade flows panel data. Halicioglu (2009) examined the causal relationship between carbon emissions, energy consumption, income, and trade using time series approach in case of Turkey. In contrast, Naranpanawa (2011) showed that trade liberalisation in Sri Lanka, has not significantly contributed to generation of CO2 emissions. Jayanthakumaran et *al*. (2012) consider similar model for China and India. Suri and Chapman (1998) find out that incorporating trade effects would tend to increase the turning point for pollutant emissions related to energy use. Choi et *al* (2010) investigates the existence of the EKC for carbon dioxide emissions and its causal relationships with economic growth and openness by using time series data 1971-2006. Depending on the national characteristics, the estimated EKC show different patterns for China, Korea and Japan. Managi et *al*. (2009) found that trade is beneficial for environmental quality in OECD countries and counterproductive in non-OECD countries in the case of SO_2 and CO_2.

Source and description of data

The data for this study come from World Bank's World development indicators (WDI) and IEA Report CO2 Emissions from Fuel Combustion (IEA, 2013). We used the following indicators:

CO2 – CO_2 emissions from fuel combustion, sectoral approach (million tonnes of CO_2), IEA
GDPPC – GDP per capita, (constant 2005$), WDI
TPES – total primary energy supply[2] (million tonnes of oil equivalent), IEA
EXPORT – export of goods and services (constant 2005 US$), WDI
TURNOVER – trade turnover, sum of export and import of goods and services (constant 2005 US$), WDI
FDI – foreign direct investment, net inflows (% of GDP), WDI

EU – dummy variable for EU members, URB – share of urban population, WDI

Our results are based on national-level data for 15 countries of the former Soviet Union collected over the period 1990 – 2011.

Empirical results

We decided to use N-shaped model because it is more general and flexible than the U-shaped one. We chose carbon dioxide emissions as dependent variable, because this global indicator is more suitable for our cross-country study.

As to controlling variables, we have already mentioned trade turnover, which may have either a negative or positive effect. It seems reasonable to include another important determinant – energy consumption because relationship between energy consumption and economic growth is revealed in many studies (Ang, 2007, 2008), (Ozturk and Acaravci, 2010), (Arouri et *al*., 2012). We conjecture positive effect on emissions. Also it is interesting to include FDI, since positive effect of FDI on pollution can indirectly speak in favor of pollution haven hypothesis, i.e. developed countries tend to relocate 'dirty' industries to developing countries, which usually have less stringent environmental regulations. It seems reasonable to introduce urbanization, which indicates demographic pressure on the environment.

The vector of controlling variables comprises energy consumption, foreign direct investment (FDI), trade turnover, urbanization and the EU membership. Our equation has the form

$$\ln CO2_{it} = \alpha_i + \delta_t + \beta_1 \ln GDPPC_{it} + \beta_2 \ln^2 GDPPC_{it} + \beta_3 \ln^2 GDPPC_{it} + \gamma_1 \ln TPES_{it} + \\ + \gamma_2 \ln FDI_{it} + \gamma_3 \ln TURNOVER_{it} + \gamma_4 \ln URB_{it} + \gamma_5 EU_{it} + \varepsilon_{it}, \quad (2)$$

[2] TPES equals production plus imports minus exports minus international bunkers plus or minus stock changes. TPES differs from final consumption in that it does not take account of distribution losses. Due to the lack of data, from here and onwards we ignore the value of distribution losses and treat TPES and energy consumption interchangeably.

To allow for heterogeneity we use fixed effects model (individual intercepts α_i can be treated as fixed parameters) and random effects model (individual intercepts α_i can be treated as drawings from distribution with the mean α). In the second type of model individual effects should be uncorrelated with regressors. We allow for both country-effects (to capture country specific factors, such as natural resources and culture) and time-effects (to capture global impacts, such as energy prices).

Estimation results (robust standard errors were used) are given in Table 1. For all specifications Hausman test and Sargan-Hansen test of overidentifying restrictions argued against random effects model, therefore we exhibit only fixed effects model results.

Table1. Fixed effect models. Estimation results

VARIABLES	(1) lnCO2	(2) lnCO2	(3) lnCO2
lnGDPPC	4.788***	5.382***	5.843***
lnGDPPC 2	-0.652***	-0.721***	-0.785***
lnGDPPC 3	0.0285***	0.0314***	0.0341***
lnTPES	1.122***	1.213***	1.143***
lnURB	1.009***	0.994***	1.162***
lnTURNOVER	0.00799		
lnFDI	8.27e-05		
EU	-0.000580		
lnEXPORT			0.0390**
Constant	-14.94***	-16.68***	-19.07***
Observations	258	327	279
R-squared	0.941	0.969	0.969
Number of id	15	15	15
Country FE	YES	YES	YES
Year FE	YES	YES	YES
P(F-test)	0.99		

*** p<0.01, ** p<0.05, * p<0.1

Starting with more general model (1), we found that trade turnover, FDI and EU membership have insignificant coefficients. After verifying joint insignificance (corresponding probability is 0.99), we proceeded to model (2). Experimenting with different measures of trade (import, export, fuel export, fuel import, merchandise exports, share of export in GDP and so on) we come to final model (3). As expected, $\beta_1 > 0, \beta_2 < 0, \beta_3 > 0,$ so N-shape hypothesis is confirmed. The first turning point is 5.44, the second one is 11.2[3]. However in our sample log of GDPPC varies from 5.33 to 9.41. Thus most of the observations lie on the decreasing branch of the cubic parabola. In other words, GDP per capita growth leads to decrease of CO_2 emissions. Typically, energy consumption growth leads to increase in pollution. Reflecting structural changes, urbanization also has positive effect. EU membership has no

[3] This corresponds to 231.29 US$ and 124007.11 US$ for GDP per capita accordingly.

effect on pollution, as well as FDI. On the one hand, the latter fact is a little disappointing, because it means that FDI does not improve technology. On the other hand, it assures that FSU countries do not become pollution haven. Unfortunately, we revealed positive dependence of the carbon dioxide emissions on export. Probably, it is due to predominance of products whose production requires large amounts of energy (ferrous metallurgy and fossil fuels extraction) in these countries' export.

Discussion and Conclusions

This paper adds some empirical evidence to the debate on the relationship between trade, economic growth and the environmental situation in developing countries.

We received confirmation that export and urbanization had positive effect on carbon dioxide emissions in FSU countries for 1990-2011. The positive impact of exports on pollution-economic growth nexus serves as an indirect proof that pollution haven hypothesis is correct. A common opinion is that the strict EU environmental legislation urges its members to reduce polluting emissions. So insignificance of EU membership is a rather unexpected result. This may be due to the following reasons. Estonia satisfies almost all of its energy needs from one of the dirtiest fossil energy sources – the shale oil (largest Europe's deposits of shale oil is located in Estonian territory). Besides in 2009 Latvia closed Ignalina Nuclear Power Plant under EU pressure, whereupon it has increased consumption of fossil fuels and, consequently, CO_2 emissions from its combustion.

We also found that the inflow of foreign direct investment does not affect air pollution. One would expect that in case of pollution haven hypothesis not only exports from the FSU, but also FDI into polluting sectors might shift Kuznets curve to the right. However, due to the lack of data, total flow of investment in all sectors was examined. It is also possible that the best indicator for the verification of this dependence is not FDI flow but FDI stocks. This requires further analysis.

Another controversial issue is the method of converting data in national currency units to a common currency for the purpose of international comparison. There are two approaches to converting GDP (and other indicators measured in monetary units): purchasing power parity exchange rates (PPP) or market exchange rates. A country's economic size, especially of a developing country, can be significantly affected by the converting method. In our study, the choice must be made for per capita GDP and turnover indicators - export and import. Choosing the market exchange rate seems natural for exports and imports since tradable goods are being traded at market exchange rates. We make the same choice for per capita GDP for two reasons. The first reason is mainly technical: it seems reasonable to us that all the variables in the regression are converted consistently. The second reason is linked to the issue of data quality. Purchasing power parity is an excellent theoretical concept, yet there are many difficulties in its measurement up to date. Deaton (2008) conducted a detailed analysis of the conceptual and measuring difficulties in calculating PPP. These difficulties comprise issues associated with cross-country comparisons of GDP components such as government services, education, health, construction and rental housing. In addition, PPP concentrates on consumer spending, while consumption of the manufacturing sector is practically ignored. Deaton (2008) puts an emphasis on the particular difficulties arising in the calculation of PPP in the countries of the former Soviet Union, which are associated with rapid changes in the economic structure and the difficulties of price collection during their liberalization. At last, it is well known that the use of PPP is most suitable in comparing countries with very different income levels, such as the US and African countries. However, in our case the income levels of the former Soviet Union did not differ that much, especially at the beginning of the transition period. Thus, arguments against the use of market exchange rates for us outweighed the benefits.

In this regard, we plan to continue testing pollution haven hypothesis in the FSU countries (not limited to the EKC methodology).

The authors are grateful to Exxon Mobil for financial support.

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