IS ECONOMIC GROWTH A CAUSE OR CURE FOR THE ENVIRONMENTAL DEGRADATION: TESTING ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS

by

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Abstract

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This paper investigates relationship between economic growth and environmental quality using the analytical framework based on the "environmental Kuznets curve" hypothesis. According to the EKC hypothesis environmental degradation has an inverse U-pattern with respect to economic growth. The EKC could be explained in terms of structural and technological changes, and more effective environmental regulation. The hypothesis is tested for local air pollutant such as sulphur dioxide using panel data for the sample of European countries including transition countries. The conclusion is twofold. First, the results imply that the effect of economic growth on the environment is subject to environmental Kuznets curve. Second, more effective environmental policies and institutions in transition countries have potential to lower an environmental price of future economic growth.

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Section 1

INTRODUCTION

Economic growth is often seen as a kind of universal cure of all problems facing Ukraine as well as other transition and developing economies. At the same time, economic growth is a cause of environmental degradation because it represents a negative externality of economic activity. At present almost all people in the world are concerned with the quality of the natural environment, deterioration of which can result in decline in the national welfare through adverse effects on human health and ecosystems.

The public-good character of environmental quality implies that public concern not necessarily translates into better environment. In western developed economies public awareness and concern on environmental issues transforms into environmental policies which impose constraints on environmentally hazardous economic decisions and create incentives to reduce environmental pollution. At the same time, the countries of Central and Eastern Europe as well as former Soviet Union countries with a long history of central planning had no effective mechanism through which public can influence economic decision-making by business and government with regard to the environmental issues. In addition, those countries undergo transition to market economy that requires significant economic transformations, and therefore, economic problems are considered to be of higher priority and should be solved to resume economic growth.

At the early stages of structural transformation all transition countries of Central and Eastern Europe experienced economic decline, that led to at least one positive outcome - improvement in the environmental quality (Hughes and Lovei, 1999). However, as soon as the country returns to the stage of economic growth, the quality of the environment starts deteriorating again. The question is whether the environmental price of future economic growth will be the same as before the "systemic transformation". This paper argues that more market-based economic interactions and efficient environmental institutions lead to a comparatively cheaper path of potential economic growth in terms of environmental damage.

We investigate the relationship between economic growth and environmental quality using analytical framework based on the "environmental Kuznets curve" hypothesis. The EKC shows that at low-incomes per capita environmental conditions worsen and then improve as economic development reaches some turning point of income per capita (Grossman and Krueger, 1995; Stern, 1996; Hilton and Levinson, 1998; Rothman, 1998). Therefore, according to the EKC hypothesis the degree of environmental impact has an inverse-U pattern with respect to economic growth.

Despite extensive literature devoted to the issue under discussion, environmental performance and its determinants during transition period deserve little attention of researchers. Previous studies of the relationship between economic growth and environmental impact consider EKC model in application to either developed or developing economies, and it has never been applied to transition countries. This paper attempts to fill this gap.

The EKC hypothesis is tested using panel data set on air pollution for the sample of 25 European countries, 10 of which are transition countries. As an indicator of air pollution we use annual emissions of sulphur dioxide released into the air at nation-wide level. This choice is justified by the fact that air pollution is one of the most severe environmental problems facing urban communities, and that sulfur dioxide pollution causes different respiratory diseases in human beings and is one of the pollutants that contribute to the acid rain problem.

The empirical results of this research support the view that environmental pollution could decline as income rises for both developed western and transition economies. However, not for all transition countries resumption of economic growth is associated with rising pollution though possibly at lower rates than pre-transition growth. Better environmental performance is observed in those transition countries where substantial progress in market reforms led to more effective environmental management, and where more incentive-based environmental policies were pursued. This implies that not only market-based relations contribute to the reduction in the environmental pollution but also effective environmental institutions do the same.

The paper is organized as follows. Section 2 provides review of previous studies concerning the economic determinants of environmental performance. Theoretical background to the EKC hypothesis is developed in Section 3. Section 4 deals with environmental practices in transition economies. Data and methodology issues are described in Section 5. The results are presented and discussed in Section 6. Conclusions and implications of the analysis implemented here are given in Section 7.

Section 2

LITERATURE REVIEW

In recent years, there have been a number of studies addressing environmental problems from a macroeconomic point of view, in particular studies investigating the relationship between economic growth and environmental performance on the economy-wide level (Grossman and Krueger, 1994; de Bruyn et al., 1998 and others). These studies hypothesize that the level of environmental pollution depends upon the level of per capita income where income is an indicator of economic growth), and on the level of population. The pattern of this relationship is argued to have inverse-U shape, and was named 'environmental Kuznets curve' (EKC)[1].

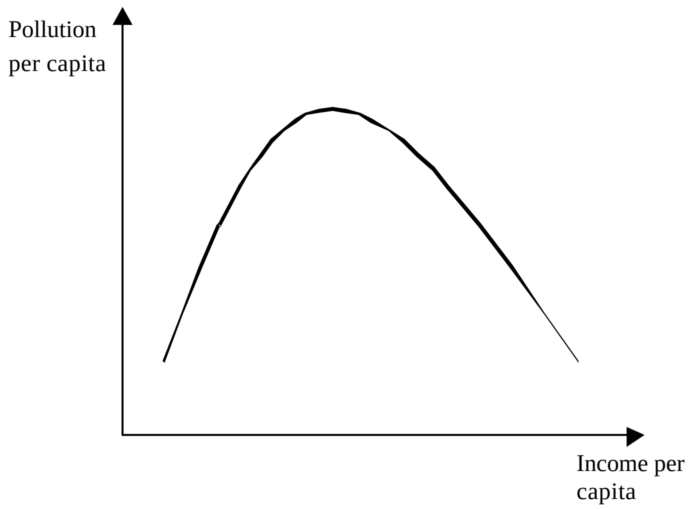

Figure 1. Environmental Kuznets curve
Source: Matsuoka et al., 1997.

The EKC become a leading hypothesis for explaining the relationship between economic growth and environmental degradation because of arisen concerns

[1] This pattern has been called the 'environmental Kuznets curve' due to the fact that environment-income relationship is similar to the pattern of income inequality with respect to time described by Simon Kuznets in 1955.

whether the world as a whole will be able to sustain rapid economic growth, given limited capacity of the environment to absorb pollution. The relationship under consideration depends upon a number of different interrelated factors such as size of the economy, composition of production and consumption, the vintage of the technology; the density of economic activity, power and income inequalities, patterns of energy use, preferences toward environmental quality, the effectiveness of regulation (Rothman, de Bruyn, 1998; Galeotti, Lanza, 1999).

Much empirical evidence was collected in favor of the EKC hypothesis over the recent years (Kahn,1995; Vincent, 1997; Hettige et al., 1997; Matsuoka et al., 1997; Stern, 1998; Galeotti, 1999) but there is a variety of theoretical explanations justifying this pattern. Researchers provide different explanations of why pollution follows this inverse-U pattern but they are considered as complementary rather than competing.

Leading explanation is that the pollution-income relationship reflects the pattern of structural change in the economy, that is pollution intensive industries are gradually substituted by clean service sectors as economy develops (Grossman and Krueger, 1995). However, Torras and Boyce (1998) argue that for this effect to be influential enough to cause pollution to decline, it must outweigh environmental impact resulting from the level of aggregate output.

Second explanation for the EKC is that production technology changes as to be cleaner and safer for the environment under the pressure of public choice of cleaner environment. Rothman and de Bruyn (1998) maintain that such technological change could be induced by more effective institutional arrangements such as pollution reduction measures implemented by government, when internalization of pollution occurs is enforced. Cleaner technologies mean not only efficiency in the use of inputs but also more pollution abatement efforts, which result in lower levels of environmental degradation. If pollution abatement effort exhibits increasing returns to scale, it is shown that pollution path with respect to income would follow an inverse-U pattern (Levinson, 1998).

Since environmental pollution is usually a result of market failure, and higher income societies are likely to be more effective in solving such problems, the EKC pattern could be the result of "more equitable distribution of power between those who bear the costs of pollution and those who benefit from pollution-generating activities" (Torras, Boyce, 1998, p. 153).

Some studies, however, argue that the income-environment relationship does not follow the conventional EKC pattern. For instance, de Bruyn et al. (1998) suggest that in the longer run an N-shaped curve would be observed, which exhibits inverted-U initially but beyond a certain income level the relationship between environmental pollution and income becomes positive. This view is rationalized by the argument that technological improvements would be eventually exhausted. In turn, Perman et al. (1995) states that EKC could appear to be a temporary phenomenon, and its pattern would change in spite of technological developments of recent years.

Traditionally, environmental pollution had been viewed as local problem in its nature, but in recent decades the problem under consideration has gone beyond the local level, and now is considered in more global dimensions. Cole et al. (1997) argue that the EKC is valid for those pollutants whose effects could be relatively easily abated (in terms of social and abatement costs) therefore Rothman (1998) asserts that pollutants, for which their impact is global in nature and costly to control do not follow Kuznets curve pattern. Ansuategi and Perrings (1999) who employ the theory of transboundary externalities to support the EKC hypothesis develop the argument that increasing integration and globalization call for more international cooperation in many fields of the economy as well as in the fields of environmental problems. And more close international cooperation would promote pollution reduction activities for global pollutants in affected countries.

Empirical studies on the issue of the EKC differ greatly in terms of approaches, methodology and data. Most of these studies use production-based approach to the determination of the EKC, neglecting the pollution that comes from consumers of goods. However, one could argue that "most of environmental degradation can be traced to the behavior of consumers either directly through the activities like disposal of garbage or the use of cars, or indirectly through the production activities undertaken to satisfy them" (Duchin, 1998 cited in Rothman, 1998 p. 182).

Matsuoka et al. (1997) find that sulfur dioxide emissions seem to have inverted-U time path as income grows, while such pollutants as nitrogen oxides and carbon dioxide have linear relation to income. Moreover, they find that deforestation ratio has no relation to economic development. Kaufmann (1998) explores the effect of income and the intensity of economic activity on the sulfur dioxide emissions. The results indicate that there is a U-shaped relation between income and sulfur dioxide emissions, but inverse-U relationship between spatial intensity of economic activity and sulfur dioxide emissions. Hettige, Mani and Wheeler (1997) study the effect of income growth on industrial water pollution. They assume that water pollution is determined by the share of manufacturing in total output and the intensity of industrial pollution. The authors conclude that industrial water pollution is more likely to have linear pattern of relationship with income.

Consumption-based measures of environmental impact such as carbon dioxide emissions, municipal waste and sewage tend to be increasing function of income (Rothman, 1998). At the same time, Kahn (1995) reveals that household-level pollution follows inverse-U-pattern while searching systematic relationship between vehicle emissions and individuals' income. He concludes that wealthier people own more vehicles and drive more, and therefore, may pollute more. And poorer households use older vehicles that produce more emissions, but they use their vehicles not so much time as wealthier people do (Kahn, 1995).

However, in an extensive survey of literature on the EKC concept Stern and Common (1996) argue that there are many problems in the empirical studies of this issue. As they state, not all studies take account of trade patterns of the countries which data were used for estimation. It is, thus, assumed that changes in trade pattern have no effect on environmental quality. In fact, although this assumption seems to be unrealistic there is little evidence existing on the significance of trade effects on environmental performance. The hypothesis that wealthier nations export pollution to less developed countries (so called 'pollution havens' hypothesis) is found to be temporary phenomenon (Mani and Wheeler, 1997). It is also assumed that there is unidirectional causality from growth to environmental quality that could appear to be false (Stern, 1998). Generally speaking, the economy and the environment are perhaps jointly determined.

Section 3

THEORY

Environmental pollution refers to those potentially hazardous "residual flows, arising from human behavior, that enter environmental systems"(Perman, 1995,p.197). The natural environment has some capacity to resist pollution created by humans, but as soon as the pollution load exceeds this capacity the environmental quality starts deteriorating. Since the earth is a closed material system, the flow of pollution could be partially transformed by the natural environment into harmless forms, but some portion may accumulate in it becoming the source of potential hazard to the environment as well as to human beings. However, the capacity of the environment to absorb pollution is limited although it varies greatly depending on the natural (climatic) as well as socio-economic factors (population density, economic activity per unit of area etc.).

The total impact of human activity on the environment is usually represented by Ehrlich equation introduced as identity in 1970s by Erlich and Holdren: I =PAT (Rothman, 1998). This equation suggests that the impact on the environment depends on the three characteristics of the economy: the amount of population (P), prosperity of the population (A) and technological peculiarities of production (T). Thus, deterioration of the environment can be directly linked to the behavior of consumers and to the patterns of production activities.

In this section we show a theoretical justification for the EKC incorporating different explanations developed in the previous studies viewing them as complementary to each other. It is shown that the EKC could be decomposed into three effects: abatement, composition and level effect. First, we show how patterns of consumer's behavior could provide rationale for the EKC. Then, determinants of the EKC are described on macroeconomic level.

Microfoundations of environmental Kuznets curve

The intuition behind the EKC could be explained using simple consumer choice model. Consider an economy with two goods: one is environmental quality (Env), another is a composite consumer good (C). A consumer can consume both goods and his preferences are described by utility function of environmental quality and consumer good: U=*f*(Env, C). The choice of consumer is constrained by his income. The consumer maximizes his utility subject to income constraint, and the optimal

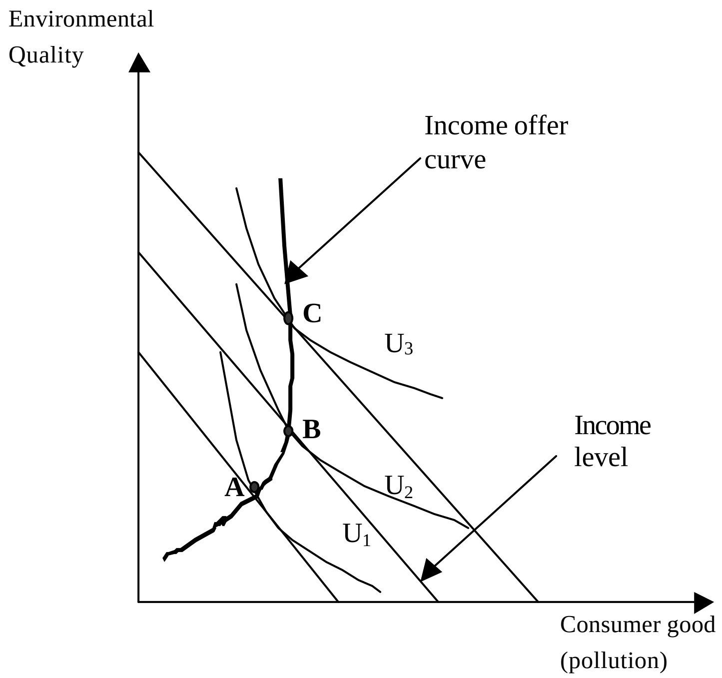

Figure 2a. Patterns of consumption of two goods: environmental quality (normal) and consumer good (inferior)

combination of consumption of both goods is a point of tangency between indifference curve and budget constraint (Pindyck and Rubinfeld, 1997). Production of consumer good is associated with environmental pollution that creates negative impact on consumer's health (Cropper and Oates, 1992). In this analytical framework we keep prices for both goods fixed as well as technology of producing good C. Thus, the production of good C causes a fixed amount of pollution per unit of output. Let us explore the relationship between consumption of good C and consumer's income holding all other things equal. By plotting the map of indifference curves and budget lines, and drawing the line through the tangency points of indifference curves and budget lines, we obtain consumption path for two goods at different levels of income and utility (Fig. 2a).

The Engel curve for good C (pollution), which relates the quantity of good consumed to income, has an inverted-U shape (Fig 2b) like Kuznets curve if to look at it so as if income is on abscissa axis. Thus, EKC could be viewed as analog of the Engel curve but the causality goes from income to consumption of good C (pollution).

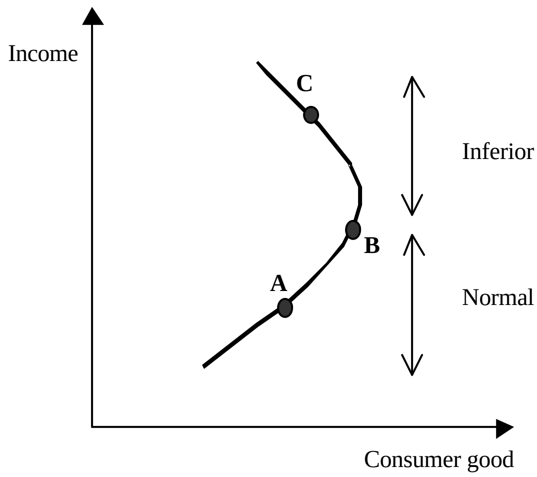

Figure 2b. Engel curve
Source: Pindyck and Rubinfeld, 1997.

Hence, at some level of income, consumer starts giving up consumption of good C in favor of environmental quality because at this point demand for environmental quality rises relative to demand for consumer good. Since prices are assumed to be fixed, change in demand affects the quantity only. However, consumer can not purchase directly more of environmental quality due to its public-good character. Demand for environmental quality translates into government regulatory measures in the absence of proper price mechanism for environmental quality.

Government regulatory actions, induced by consumers willingness to have better environmental quality, cause producers of good C reduce pollution embodied in each unit of their output. Production theory predicts that "pollution-control measures should be pursued by each polluting agent to the point at which the marginal benefits from reduced pollution summed over all consumers and all firms equal marginal abatement cost"(Cropper and Oates, 1992, p.679).

Thus, the efficient level of pollution will be the level, which maximizes the net benefit of the pollution flow that equal to benefit of the output with which the pollution is associated less damages resulting from the pollution. However, achieving efficient level of pollution critically depends on the ability of government to impose socially optimal constraint on the production decisions of different firms.

Macroeconomic determinants of the EKC

Traditional analysis of the environmental externalities problem gives us conditions that yield efficient outcome at a given point of time at firm level. However, market outcomes could be not time invariant. Production decisions of firms are subject to changes in response to fluctuations in the demand, relative price changes, resource scarcity, technology improvements and changes in government policies. Thus, the level of environmental externalities produced is likely to change over time. The time path of both output and pollution could be derived by solving dynamic utility optimization problem. The optimal path of environmental pollution flow requires some level of abatement efforts (no matter whether they are exogenously induced), preferences of consumer toward consumption of good and pollution, and the rate of capital stock accumulation (Selden and Song, 1995). However, it is beyond the scope of this work to look for the optimal path of the pollution over time at rising income levels.

The environmental Kuznets curve shows the net effect of economic growth on the environment. This could be decomposed into several effects to describe complex environment-economic interactions. Following Islam, Vincent and Panayotou (1999) we represent the EKC as a combination of three effects: level effect, composition effect and abatement effect.

The level effect, captured by level of income per unit of area, refers to income as an indicator of the level of economic activity within the given area. Since all economic activities are considered to be to certain degree pollution generating thus the higher the activity on the given area, the higher will be the level of pollution. Due to level effect pollution is likely to increase monotonically with income level per unit of area in linear fashion (Fig. 3a).

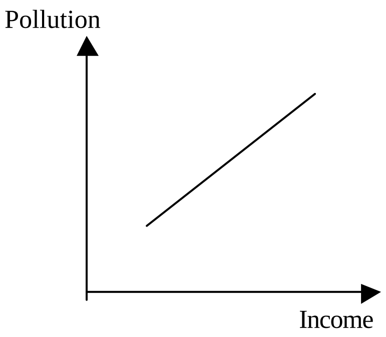

Figure 3a. Level Effect
Source: Islam N., J. Vincent and T. Panayotou, 1999.

Composition effect takes place if the pollution-income relationship reflects the pattern of structural change in the economy; that is, pollution intensive industries are gradually substituted by clean service sectors as economy develops. Assuming that industry generates more pollution than other sectors of the economy this implies that pollution-income relationship has inverted-U shape (Fig. 3b).

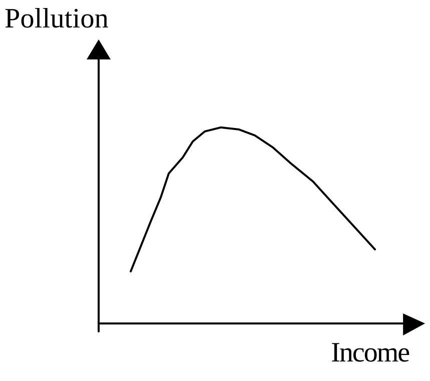

Figure 3b. Composition Effect
Source: Islam N., J. Vincent and T. Panayotou, 1999.

Abatement effect: The rationale behind abatement effect is explained in the microfoundations of the EKC. Higher-income groups demand more environmental quality. And abatement efforts become more substantial at higher income levels since there are more resources available for investment in clean technologies and R&D, and environmental regulator (as becomes better funded) provides incentives for pollution reduction. Due to abatement effect pollution is likely to have inverted-J relationship (Islam et al., 1999) (Fig. 3c).

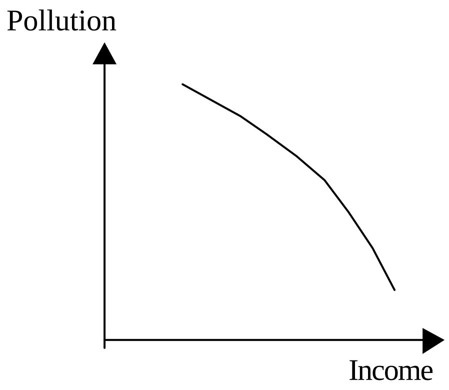

Figure 3c. Abatement Effect
Source: Islam N., J. Vincent and T. Panayotou, 1999.

The overall income-environment relationship would follow conventional inverted-U pattern when abatement effect outweighs level effect. As soon as abatement opportunities are exhausted, the level of pollution might go up. If such outweighing is observed for a certain income range then the EKC is likely to be N-shaped.

Algebraically, the relationship between pollution and income could be represented as follows:

$$P_A = E/S = (Y/S) \times (E/Y), \quad (1)$$

where

P_A - ambient pollution level

S - area, on which pollution is generated

Y - income level

E - pollutant emissions

E/Y - pollution intensity of income

Pollution intensity of income depends on the extent of pollution-generation activities (pollution generation (P_G) per unit of income) and pollution-abatement efforts:

$$E/Y = \{P_G/Y\} \times \{E/P_G\} \quad (2)$$

Hence,

$$P_A = E/S = \{Y/S\} \times \{P_G/Y\} \times \{E/P_G\} = L \times I \times A \quad (3)$$

Where the first term represents level effect (L), the second - composition effect (I), and the third - abatement effect (A).

Section 4

ENVIRONMENTAL PRACTICES IN TRANSITION COUNTRIES

During the transition from central planning to market-based economies, governments in the Central and Eastern European countries have been faced with the difficult task of balancing environmental concerns with economic development. Economic recession in transition countries has brought about a downward trend in the levels of pollution from industrial sources (REC[2], 1998). The major focus has primarily been on the process of economic reform and restructuring, and creating private ownership and economic competition, and it was expected that this process would contribute to further improvements in environmental conditions.

After the years of central planning, transition countries have to withstand "a legacy of inefficient industries, obsolete and polluting technologies, and weak environmental management and regulation" (Hughes and Lovei, 1999, p.1). In these effort governments and other economic agents in transition countries are supported by the international community. In 1993 the Environmental Action Program was initiated during the international conference "Environment for Europe" in Lucerne, Switzerland. The attention was focused on a number of environmental problems but as the most important they viewed high levels of air pollutants emissions such as sulfur dioxide and airborne particulate matter emitted from power and industrial plants, and drinking water contamination by heavy metals, nitrates and other toxic chemicals (Hughes and Lovei, 1999).

The positive impact of economic reforms would be stronger if effective

[2] Regional Environmental Center (REC) for Central and Eastern Europe

environmental policies, institutions and investments are implemented. Only recently did national governments switch to an integrated approach to the economy and environment which stipulates for the use of both regulatory (command-and-control) and economic (incentive-based) instruments for environmental protection measures. Over the last 5 years transition countries have taken steps toward harmonization of legislative base with the one of European Union, and have joined to a number of international agreements (REC, 1998).

In advanced reform countries such as Poland and Czech Republic air pollutant emissions were falling more rapidly than GDP. At the same time, in slower reformers such as Ukraine emissions of air pollutants are falling approximately in line with GDP (Piontkivska et al., 2000; Hughes and Lovei, 1999). This suggests that more successful market reformers succeed also in pollution reduction activities because of new technologies and more compliance with environmental regulatory requirements.

However, the lack of integrated approach to environmental protection programs and low environmental awareness of the public could lead to change in declining pollution emissions trends. Moreover, consumers tend to believe that prospering economy can solve all social problems, including environmental ones. Regional Environmental Center (REC, 1995) stresses that although the majority of citizens support sound environment, their consumption patterns has changed towards more wasteful and less environmentally friendly habits.

Given this evidence, we could expect that transition countries are likely to be either on the increasing part of environmental Kuznets curve or just switch over the peak. For illustration purposes we plot the scatter diagram of sulfur dioxide emissions per capita and income per capita for all countries and period we have in the sample (see Fig. 1 in Appendix 2). In principle, the picture resembles non-linear relationship between pollution and income justified by theory.

Section 5

DATA AND SPECIFICATIONS

Data

All data used for this research are aggregate national level data for 25 western and transition countries. For estimation purposes the total sample is divided into two subsamples named 'western' and 'transition'. The list of countries included in the sample is presented in Appendix 1 (see notes to Table 1). Due to the fact that long time series on the relevant variables are difficult to get for individual countries, there is rationale to use panel data. In addition, there are some breaks in the data for transition countries, so the panel is unbalanced. Data summary is presented in Table 1 of Appendix 1.

As a measure of environmental impact we use data on emissions of acidifying air pollutants, in particular SO2 emissions from anthropogenic sources (in kg/capita). The aggregate annual emissions data for Western, Central and Eastern European countries are taken from CORINAIR database of the European Environmental Agency for the years of 1980, 1985 and 1990-1997. The source of SO2 emissions in Ukraine data over the relevant periods (1980, 1985, 1990-1997) is State Statistics Committee of Ukraine. Although Ukrainian emissions data come from other source we view all data within our data set as comparable since CORINAIR database is constructed using data submitted by the national governments. Then, aggregate annual emissions data were transformed into per capita terms using population data for the relevant countries and periods taken from World Development Indicators (CD-ROM WDI, 1999).

Proxies for income-related explanatory variables are as follows:

- for *abatement effect* we use GDP per capita measured in PPP adjusted international dollars;

- for *composition effect* we use industry value added as a percentage of GDP;

- for *level effect* we use GDP per kilometer squared (constructed by multiplying GDP per capita and population, and then dividing by surface area).

All the data for construction of income-related explanatory variables are taken from World Development Indicators 1999 (WDI, 1999).

For the sub-sample of transition countries several additional variables are introduced in order to separate the effect of transition process and institutional development on the environmental performance, although it is quite difficult to measure these effects.

Private sector share in GDP in transition countries is viewed as a proxy for progress in market reforms that bring out more efficient allocation of resources and more environmental requirements compliance. Data on private sector share in GDP come from various issues of EBRD Transition report for the period of 1994-1997. Since the period for which these data are available is rather short, the number of observations in time dimension is significantly reduced.

Environmental regulation index is a qualitative measure of development and effectiveness of environmental institutions in provision of environmental quality and promotion of pollution reduction. It aims at assessing the relative progress made in adopting an environmental protection strategy, which is consistent with a market-based economic performance. The index is constant over time, and varies in cross-section dimension. It is composed on the basis of information provided in UNCED country reports and publications of

Regional Environmental Center for Central and Eastern Europe by assessing the status of environmental policy and national environmental action plan, the scope of environmental awareness, the enforcement mechanisms etc. Total number of categories assessed is 10. The status of each category is graded on different scales depending on the importance of the category. The index is computed so that the higher value implies more advanced environmental institutional framework. Table 2 in Appendix 2 shows values of environmental regulation index for 11 transition countries included in our sample. The index construction technique represents modified version of the one used in the cross-country study by Dasgupta et al. (1995).

Specifications

Earlier analyses use a variety of specifications to estimate the relationship between income and pollution. Here we develop the specifications that are consistent with both previous studies and our theoretical framework. In theoretical part of this research we specify that environmental pollution level is a non-linear function of income and also other factors, and all those factors have multiplicative effect on pollution level.

In previous researches the EKC of conventional inverted-U shape is modeled as second-degree polynomial in logarithmic terms (Hilton and Levinson, 1998; Perman and Stern, 1999)[3]:

$$lnE_{it}=\boldsymbol{a}+\boldsymbol{b}_1(lnY_{it})+\boldsymbol{b}_2(lnY_{it})^2+\boldsymbol{e}_{it},\qquad(4)$$

where E is pollutant emissions per capita, Y is income per capita, the subscript i stands for country index, t is a time index, ε is the composite normally distributed error term. According to a prior expectations the signs of

3 Non-logarithmic specifications were also used in other studies. The use of log-log specification makes it easier to interpret the regression coefficients.

the coefficients must be as follows: $\boldsymbol{b}_1>0$ and $\boldsymbol{b}_2<0$. Time effects in this model are captured by an intercept term. Alternative specifications In previous studies included non-income determinants of the EKC such as population density, urbanization rate, energy use, climate etc. However, in this study we will concentrate on the factors that are either theoretical determinant of the pollution-income relationship or specific to the transition countries, which represent our particular interest.

As we show in Section 3 total income effect on pollution level (E) could be presented as multiplication of level (L), composition (I) and abatement (A) effects:

$$E = L \times I \times A \qquad (5)$$

To separate three different effects and to enable the use of multivariate linear regression technique logarithmic transformation of the identity (5) is performed, so that the terms become additive. In addition, theoretical determination of the shape of the curves representing different effects leads us to the following empirical model:

$$lnE_{it} = \boldsymbol{a} + \boldsymbol{b}_1 ln\ L_{it} + \boldsymbol{g}_1 ln\ I_{it} + \boldsymbol{g}_2 (ln\ I_{it})^2 + \boldsymbol{q}_1 ln\ A_{it} + \boldsymbol{q}_2 (ln\ A)^2_{it} + u_{it}., \qquad (6)$$

where L- variable that captures level effect (GDP/area), I –variable that captures composition effect (industry value added), A - variable that captures abatement effect (GDP/capita), E-pollutant emissions per capita, u- an error term. Since industry value added is expressed as a percentage of GDP we will not take a logarithm of the variable I during estimation.

For transition-specific estimation we include two more terms that account for environmental institutional arrangements and progress in transition to market economy. We view these factors as contributing to the abatement efforts within the economy:

$$lnE_{it}=\alpha+\beta_1 lnL_{it}+\gamma_1 lnI_{it}+\gamma_2(lnI_{it})^2+\theta_1 lnA_{it}+\theta_2(lnA)^2_{it}+\theta_3 ER_i+\theta_4 PRI_{it}+\varepsilon_{it}. \quad (7)$$

where ER is environmental regulation index and PRI is private sector share of GDP.

The expected signs of the coefficients are as follows:

1. The level effect coefficient is expected to be positive ($\beta_1>0$) assuming that each unit of the output produced is associated with certain fixed portion of pollution.

2. The composition effect is restricted to have inverted-U shape, so the signs of coefficients that fit this shape are $\gamma_1>0$ and $\gamma_2<0$.

3. The abatement effect is presented with the help of two terms (linear and quadratic), so that the shape of the curve is concave and decreasing. For this to hold true, the coefficients must be as follows: $\theta_1<0$ and $\theta_2>0$.

4. The effect of environmental regulation index and private sector share of GDP on pollution is expected to be negative: $\theta_3<0$ and $\theta_4<0$.

5. An intercept term α captures both country-specific and time effects. If pollution load declines over time in most of the countries included in the sample, then $\alpha<0$. If $\alpha>0$, the opposite is true.

The sample we use for estimation is rather heterogeneous, that is combined with the wide range of income levels and emissions. Therefore, there is a good reason to believe that the error terms, estimated from pooled data using OLS, are not homoscedastic. Hence, there is a rationale to use GLS estimation technique. We do not perform test for non-stationary for our time series because the time dimension of the panel we use is rather short (less than 10 observations) and there are missing observations in the panel.

Section 6

RESULTS DISCUSSION

The model specifications (4), (6) and (7) have been estimated for patterns of sulfur dioxide emissions in western and transition countries for periods of 1980, 1985 and 1990-1997. The estimation results are presented in Table 3 in Appendix 4. The signs of the relevant variables are in line with our prior expectations. Due to strong multicollinearity between income-related variables (GDP per capita, GDP per sq. km and industry share of GDP), it is difficult to infer much about the individual coefficients. Even with small absolute values coefficients turn out to be statistically significant. However, we can look at relative sensitivity of air pollution to changes in income-related factors. So, it turns out that income per capita, spatial intensity of economic activity (GDP/area) and industrial output are important determinants of sulfur dioxide emissions per capita.

The column 1 of the Table 3 presents estimated coefficients for equation (4). For the sample of transition and western European countries evidence in favor of conventional inverted-U EKC was found. We perform this estimation to compare the results with those obtained in other studies. It appears that the values of our coefficients are a bit higher than those reported by Grossman and Krueger (1995), Matsuoka et al. (1997). This implies that the EKC is more concave in our case. If we take income level of $3000 per capita like in Ukraine (in PPP terms), then increase in income by $100 causes 0.67% increase in sulfur dioxide emissions per capita. With rising income this value will get lower until turns to negative. Intercept term is negative suggesting that there may be downward trend in sulfur dioxide emissions that is independent of income per capita. The graphical illustration of the estimated EKC from this regression is presented in Figure 2 in Appendix 5. Turning point is about $ 6000 per capita in PPP terms.

Column 2 presents regression results for the model specification (6) where we include variables capturing level, composition and abatement effect. Since all variables but those expressed in percentages, were transformed into logs, the values of coefficients are corresponding elasticities. Industry share of output which captures composition effect is found to follow inverse-U pattern, both coefficients are statistically significant and have correct signs. However, the value of the coefficients is rather small relative to others implying that composition effect has fairly small weight in the overall pollution level. The effect of GDP per unit of area is found to have statistically significant positive impact on sulfur dioxide emissions per capita like it is predicted by theory. The higher is the level of output produced per unit of area the higher will be pollution level. For instance, 1% increase in the amount produced on the given territory results in 0.055% increase in sulfur dioxide exposure of each person. Abatement effect captured by income per capita appears to be the strongest determinant of the sulfur dioxide emissions relative to level and composition effect. The shape of the estimated abatement curve implies that abatement efforts are insufficient to restrain rise in pollution until a certain level of income is reached, then abatement efforts become more effective in pollution reduction.

For the sub-sample of transition countries two estimations were performed. In columns 3 and 4 of Table 3 we present the estimation results for equation (7) where we first include only environmental regulation index, and then add private sector share as explanatory variable. The reason for this procedure is limited availability of the data on private sector share in total output, that significantly reduce the number of observations. So, to avoid this loss of degrees of freedom that could result in lower statistical significance of our coefficients, we omit this variable first.

The impact of environmental regulation is consistent with our hypothesis. In transition countries, better environmental management is statistically significantly associated with reduction in pollution levels. One unit increase in environmental regulation index causes 0.03% reduction in sulfur dioxide emissions per capita. The relative extent of this impact is enough to cancel out the positive influence of the level effect (GDP/sq.km). It should be noted that in order to make strong policy implications there is a rationale to perform cost-benefit analysis for the set of environmental policy alternatives. For transition economy it is quite challenging task because less environmental regulation may let the economy grow faster. However, the World Bank experts emphasize that "the gains from protecting the environment are often high and that the costs in forgone income are modest if appropriate policies are adopted" (World Bank, 1992)[4].

Private sector share as an indicator of progress in transition to the market has slightly negative but statistically significant impact on the level of pollutant emission per capita. For instance, 1% increase in the share of private sector results in 0.009% reduction in sulfur dioxide emissions per capita. Although the value of the coefficient is pretty small this result is consistent with the hypothesis that more market-based economic interactions contribute to reduction in air pollution, and it provides evidence that progress in transition to market economy has positive impact on the environmental quality.

It was also found that the values of income per capita coefficients (which capture abatement effect) are lower for the subsample of transition countries then the same coefficients estimated using the total sample. This result implies that the abatement effect curve in transition economies has smaller values of slope. In other words, abatement efforts on margin produce smaller impact on the level of pollution. The possible explanation

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[4] Cited in Meier G.M.,and J. E. Rauch. 2000. Leading Issues in Economic Development -7th ed.-Oxford University Press. p.520.

of this is that technology of abatement used in transition countries is less efficient in pollution reduction.

In sum, our results provide fairly good support for the EKC hypothesis and importance of proper regulatory policy for achieving environmentally friendly economic growth.

Section 7

CONCLUSION

This study aims at analyzing the relationship between economic growth and environmental quality to provide theoretical and empirical justification for the environmental Kuznets curve hypothesis. The focus of this paper is made on the patterns of this relationship in transition countries. Specifically, we have quantified the effect that income per capita, structural change and environmental institutions development have on sulfur dioxide emissions. The results reported here imply that first, the effect of economic growth on the environment is subject to environmental Kuznets curve, which suggests that rising per capita income can be accompanied by improvements in air quality; second, improvements in environmental management play an important role in this outcome.

Environmental quality is conditional upon such non-income factors as environmental awareness and public initiative, environmental regulation effectiveness. However, non-income determinants of environmental quality do not destroy the pure income effect. Thus, individual demand for environmental quality may rise with income. And this increase may be stronger than demand for other goods and services, the production and consumption of which generate pollution.

Since environmental quality is a public good, the effective demand for it requires strong environmental institutions. It was found that more effective environmental regulation contributes to pollution reduction. Other things being equal, better environmental regulation tends to decrease sulfur dioxide emissions in transition countries. This gives rise for rather useful implication for Ukraine. Recent evidence suggests that the year 2000 could be the first year of positive economic growth in the history of independent Ukraine. So, by implementing proper environmental policy Ukraine has a potential to lower environmental price of economic growth.

Finally, it is worth citing Grossman and Krueger (1995) who stress that "low-income countries of today have a unique opportunity …to avoid some mistakes of earlier growth experiences. With the increased environmental awareness of environmental hazards and the development in recent years of new technologies that are cleaner than ever before, we might hope to see the low-income countries turn their attention to preservation of the environment at earlier stages of development than has previously been the case" (p.372). However, to address environmental problems effectively strong institutions should be developed so that policies that are justified on economic grounds can complement those for environmental protection. The key role for environmental institutions is to provide incentives rather than direct regulations to protect environment.

In transition countries the use of economic incentives, enhanced penetration of new technologies, increased public awareness and understanding of environmental problems and its consequences as well as promotion of energy efficiency are important pollution prevention measures that could deliver the desirable outcomes in terms economic growth and natural environment.

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Appendices

Appendix 1

Table 1. Data summary

Variable	Unit of measurement	Mean			N	Source
		total	transition[1]	western[2]		
SO2 pollution	kg/capita	58.6	88.7	34.5	237	European Environmental Agency, 1999[3]
Income per capita	$/capita (PPP, current international prices)	11 549	5080	16 523	217	World Development Indicators, 1999
Industry value added	% of GDP	36.4	43.3	30.1	157	World Development Indicators, 1999
Spatial intensity of economic activity (GDP/area)	000$/sq. km	26 055	476.9	44 325	228	World Development Indicators, 1999
Environmental regulation index			11.36		11	UNCED Country Reports, Regional Environmental Center, 1995-1997
Private sector output	% of GDP		57.75		39	EBRD Transition Reports, 1994-1997

Notes:
[1]Sample of transition countries includes: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia, Ukraine.

[2]Western countries included in the sample are Austria, Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, Great Britain, Greece, Ireland, Italy, Netherlands, Sweden.

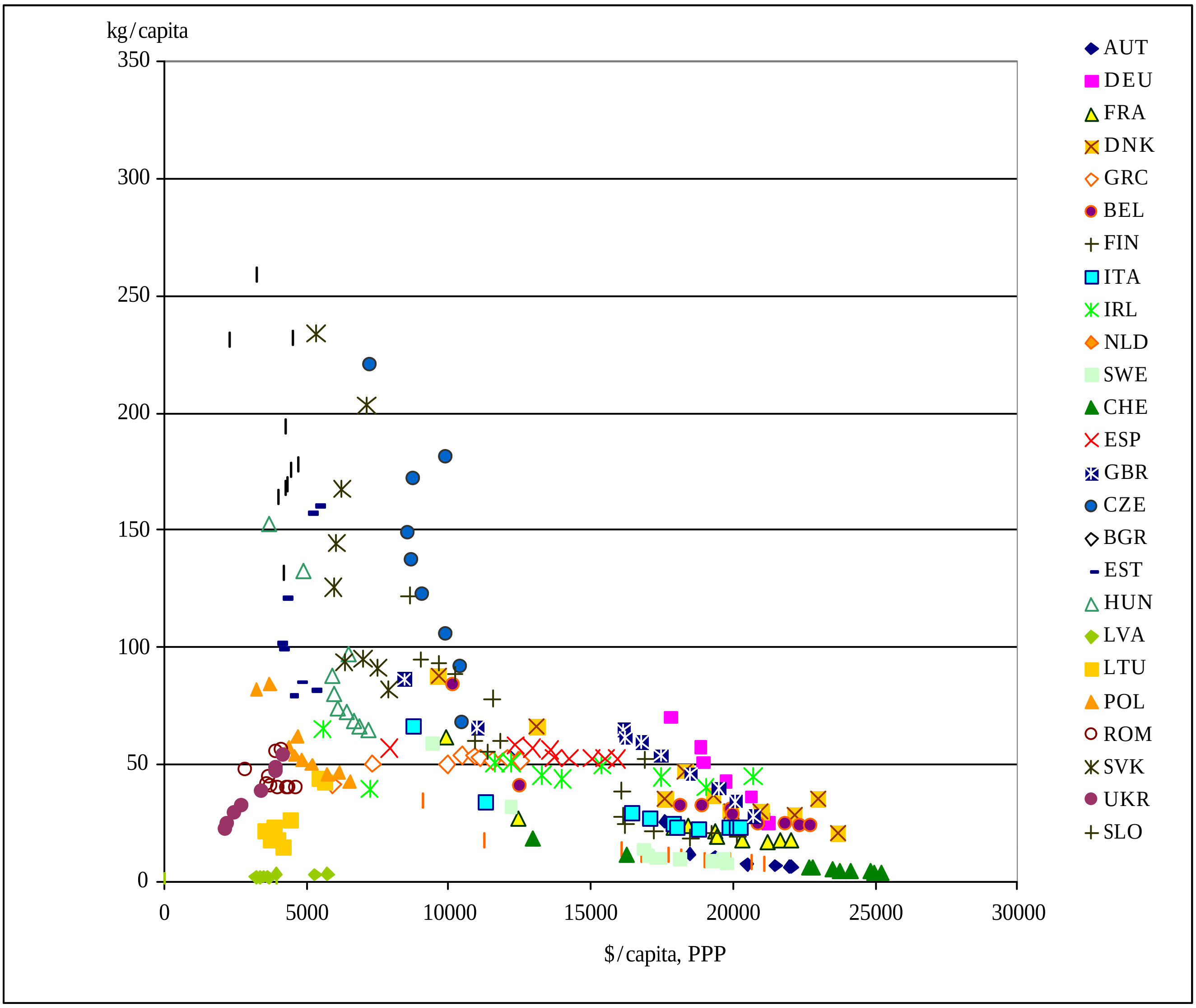
Appendix 2

Table 2. Environmental regulation index for transition countries

	Bulgaria	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovak Republic	Slovenia	Ukraine
Environmental awareness	1	1	2	2	2	2	1	2	1	2	0
Air pollution as a national priority (Yes=1, No=0)	1	1	0	0	1	0	1	1	0	1	1
Environmental framework law	2	1	1	3	2	1	3	3	1	1	1
Expenditure on pollution control and abatement	1	3	1	1	2	2	2	1	2	1	1
Use of economic instruments	1	2	1	1	2	2	2	1	1	0	2
International treaties	1	2	2	2	1	1	2	2	2	1	2
Environmental institutions development (powerful agency=1, otherwise=0)	1	1	1	1	1	1	1	0	1	0	1
Environmental data availability (Free access=1, otherwise=0)	1	1	0	1	1	1	1	0	1	1	0
Public participation and initiative (Extensive=1, otherwise=0)	1	1	0	1	1	0	1	0	0	0	1
NEAP preparation (Complete=1, Incomplete=0)	1	1	1	1	1	0	1	1	1	1	0
TOTAL	11	14	9	13	14	10	15	11	10	8	9

Source: composed by the author on the basis of information of Regional Environmental Center for Central and Eastern Europe, UNCED.

Figure 1. The relationship between income (US $ per capita) and sulfur dioxide emissions (kg/capita) in European countries[1]



[1] The data presented are for the periods of 1980, 1985 and 1990-1997.

Appendix 4

Table 3. GLS estimation results*

Dependent variable = ln (SO2 emissions per capita)				
Explanatory Variable	1**	2	3***	4***
GDP per capita	**16.77861**	**11.61977**	**1.205318**	**2.647908**
	4.556293	*2.854834*	*2.854804*	*3.04097*
GDP per capita squared	**-0.96559**	**-0.673254**	**-0.08382**	**-0.18033**
	-4.75044	*-2.94077*	*-2.75645*	*-2.92854*
GDP/area		**0.055807**	**0.049549**	**0.056516**
		1.802326	*1.508879*	*1.306521*
Industry		**4.53E-07**	**0.01458**	**0.014869**
		2.821987	*3.657455*	*1.390846*
Industry squared		**-1.89E-15**	**-0.00073**	**-0.00083**
		-2.841099	*-2.89875*	*-1.28454*
Environmental regulation index			**-0.04837**	**-0.0309**
			-4.90602	*-1.55878*
Private sector output				**-0.00922**
				-1.66093
Intercept	**-82.3771**	**-60.18628**	**-3.68186**	**-9.09018**
	-4.96213	*-3.21589*	*-2.46977*	*-3.039*
R-squared	0.316525	0.286637	0.231769	0.318355
DW	1.287	1.5020	1.1618	0.9351
# of obs	205	145	62	25

Notes:

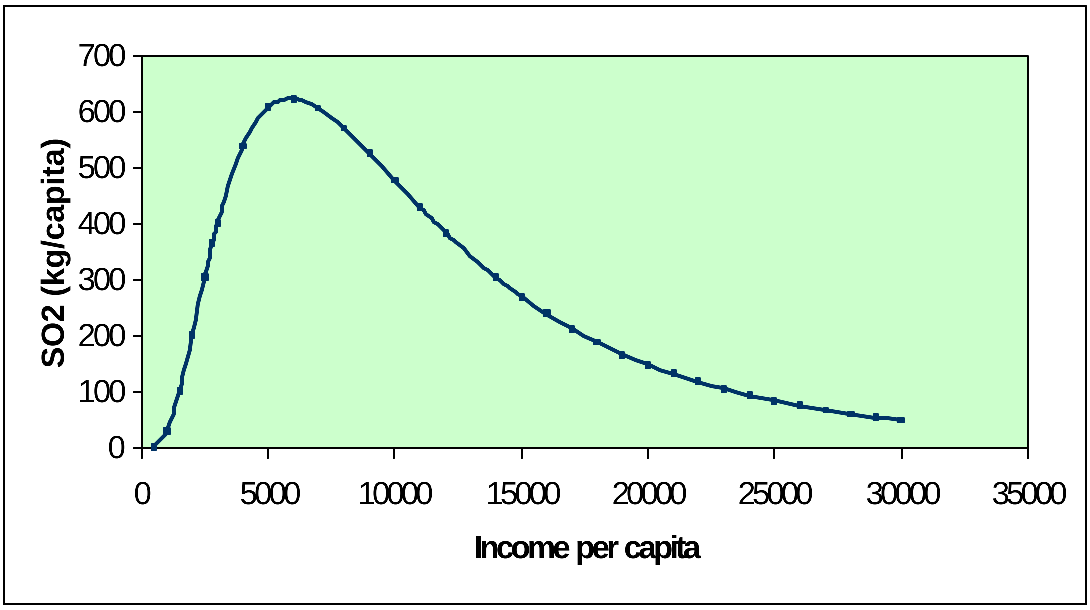
*GDP per capita, GDP per capita squared and GDP/area variables are in logarithms. Values in italics are t-statistics.

** This specification is performed using the sample which includes both western and transition countries for comparison purposes, where income per capita captures the net effect of economic development on the air pollution.

***In both models we detected first order serial correlation in the residuals. In the presence of autocorrelation OLS estimators are unbiased and consistent but no longer efficient (Gujarati, 1995). In order to correct this problem we specify an error structure as following: $\varepsilon_{it} = \rho\varepsilon_{it-1} + u_{it}$, where $|\rho|<1$, and $u_{it} \sim IID(0, \sigma^2)$. It is assumed that each country have the same autocorrelation parameter (ρ). However, even after the remedial measures, DW-statistics remains a bit low; the reason for this is that autocorrelation parameter differs across the countries included in the sample and possibly due to rather small number of observations in time dimension.

Appendix 5

Figure 2. The estimated Environmental Kuznets curve *



*ln(SO2/capita)=-82.3771+16.77ln(GDP per capita)-0.96(lnGDP per capita)^2
** Estimated sulfur dioxide emissions are in normalized values.