MODELING THE SUSTAINABLE DEVELOPMENT WITH THE ECOLOGICAL KUZNETS CURVE

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Influence of per capita income on pollution is modeled with the help of the Environmental Kuznets Curve (EKC). The EKC pattern suggests an inverted U–shape relationship between per capita income and pollution. The main findings is that Ukraine follows the EKC pattern for some pollutants such as SO2, NO2, IZA while there is an increasing pattern for other pollutants such as dust, CO2.

The description of the modelling for Ukraine includes two sets of results: (i) the one associated with pollution expressed as concentrations (a city level analysis), and (ii) another one associated with pollution in terms of emissions (a regional level analysis). First, we run linear regressions and show that the linear model is misspesified. Second, we provide the description of the basic model that contains only income as a major explanatory variable and pollution in terms of concentrations. After that, we test the hypothesis of the EKC on the basis of simultaneous equations model. In the latter, *income* is influenced by the key factors such as assets per capita, the VCV and pollutants; in turn, pollution is determined by the VCV and income. Finally, we discuss the obtained results in terms of break point analysis.

The pollution-income relationship was specified in the usual way as quadratic and logarithmic relationship. Both representations were estimated, but only linear relationship showed the EKC pattern (logarithmic model did not support the EKC hypothesis). Inclusion of the Vector of Climate Variables (VCV) into the model did not change much the value of coefficients associated with income. For models exhibiting the inverted U-shape relationship we have estimated break points, and they appeared to be in the range $2000-$5000 in 2007 prices. Our findings are comparable with the earlier studies that estimated beak points at $1000-$80000US. For example, Feng and Show (2004) estimated break point for CO in Taiwan at $6000. According to Egli Hannes (2004), the break point for NO_x in Germany was estimated at US$14750 (in 1985 prices), break point for NH3 was at US$17000 (in 1985 prices). List, Millimet al., (2003) performed the EKC modelling for the US, and the estimated break points were at US$5000-20000 (in 1987 prices).

The crucial question that may arise is: Why Ukraine has such small value of break points in comparison with other countries? One possible answer is that oil and natural gas prices are constantly increasing in Ukraine, and Ukrainian businesses are forced to use more energy effective technology which is also more environmentally friendly. Below we provide examples of the largest Ukrainian corporations that started to implement more energy effective equipment according to Rozhin (2007). "Thus "Mariupol Illich Steelworks" in June 2006 started to introduce pulverized coal injection on its blast furnaces. "Yenakievskiy Steelworks" is building coal-dust complex. "Mittal Steel Kryvyi Rih" switches its blast furnaces from gas to coke of higher quality. According to the steel plant announcement it is going to invest 325 million in modernization. It will lead to economy of about 190 thousand cubic meters annually. "Donetsk Steelworks" completely switched from gas to coal-dust fuel. "Alchevsk Steelworks" is going totally invest 1.4 billion dollars over the period of 2007-2010. It is going to decrease gas consumption by 80 percent. "Azot Cherkasy" is investing 400-600 million dollars during the period 2007-2010. The main aim of the program is to cut high energy costs."

Found values of the break points in Ukraine on the basis of the EKC are smaller than those in developed countries, which may suggest that Ukraine follows its own pattern in economic development.

Our assumption about the omitted variable bias failed to be supported by Ukrainian data on pollution (in terms of concentration). The difference in break points with and without VCV disappears in one or two years.

However, the VCV happened to be important in GLS estimation of the EKC: Wind, smog, and precipitations showed expected results. Random effect showed insignificant influence of the VCV.

The main prediction of our findings based on the EKC is that pollution by SO2 and NO2 should start to decrease in the nearest future, while pollution by CO2 and DUST is going to increase. There is a specific case with dust which failed to support the EKC hypothesis under usual assumption (pollution does not influence per capita income), but showed the inverted U-shape relationship under the instrumental variable approach (break point was at the level of UAN 22433).

The overall emission pattern did not decrease during the 1998-2006; on the contrary the emissions were increasing, which may suggest about the development of new chemical and metallurgical industries. We assume that economic recuperation of Ukraine starting from 1999 increased pollution in terms of one pollutants (CO2, dust, CO and some others), and possibly slow down the in terms of others (SO2, dust, NO2). Actually it's very difficult to compare the concentrations and emissions, because data for the concentrations is measured exactly in the cities, while emissions are from firms that belong to some specific city, but they are not necessary to be within the city (usually outside).

The emission data set failed to support the EKC, showed a sustainable plateau in pollution in the range of UAN 1000-15000 (in 2007 prices). It suggests that the automobile pollution should start to decline in Ukraine beyond income level of UAH 15000.