Arnold BERNACIAK
Poznań University of Economics (Poland)

# THE ENVIRONMENTAL KUZNETS CURVE IN TRANSITION COUNTRIES ON THE EXAMPLE OF POLAND

## 1. Introduction

The relation between economic growth and environmental pressure has caused a great deal of queries and controversies for a number of years. The possibility for growth in the context of depleting natural resources was considered in classic economics texts – *e.g.* Thomas Malthus, David Ricardo and John Stuart Mill. Recently many environmental economists have been working on these issues. Some of them show the negative environmental consequences of growth, emphasizing that it does not lead to reaching social goals [*e.g.* Mishan, 1967; 1977; Schumacher, 1973; Daly and Townsend, 1993]. Others point out that it is impossible to sustain growth in the long run [*e.g.* Meadows et al., 1972; 1991; 2004; Arrow, 1995]. Other environmental economists highlight the chance of reconciling economic growth with the requirements of environmental protection [*e.g.* Simon and Kahn, 1984; von Waiszacker et al., 1997], or even state that economic growth is necessary to keep environmental quality at a high level [Beckermann 1992].

The relation between economic growth and environmental pressure is illustrated by the environmental Kuznets curve. The existence of this curve is purely a scientific hypothesis. Research conducted in order to verify it empirically has equally confirmed and negated its existence. But every global research project rejected data from transition countries as too atypical, distorting the results. Consequently, the relation between economic growth and environmental pressure in countries going through the process of transition from a centrally planned to a free market economy has never been analysed.

This article deals with the issue described above. Taking the Polish economy as an example, it attempts to answer the following question: what is the form of the relation between economic growth and environmental pressure in the period of transition.

## 2. The concept of the environmental Kuznets curve

The environmental Kuznets curve (EKC) illustrates the relation between economic growth (Y), for the sake of simplicity equated with welfare, and environmental pressure (EP). Economic growth (welfare) is represented by GDP per capita. Environmental pressure is defined using a range of indicators of an economic system's impact on its natural surroundings. Graphically, it may be visualized as an inverted U curve. The relationship between environmental pressure and economic development is similar to the link between income inequality and per capita income suggested by Simon Kuznets [1955]. That is where the curve's name comes from.

For many years it was thought that the consumption of natural resources and energy grows at nearly the same rate as economic growth. In the 1960s this triggered intensified concern regarding the availability of the Earth's natural resources and the possibility of their undisturbed economic use. This resulted in a variety of publications, including the famous report *Limits to Growth* [Meadows et al., 1972]. Meanwhile, research conducted by Malenbaum [1978] proved that in developed economies the consumption of particular metals has decreased in the course of the development process. This contradicted the statements of *Limits to Growth*, which caused Malenbaum to mathematically describe the relation between income and the intensity of metal use. The inverted U-shaped curve representing this relationship shows that after the socioeconomic system has reached a certain level of income, the intensity of the consumption of particular metals declines.

Empirical evidence has also been found for an inverted U-shaped relation between other types of environmental pressure and income [Grossman and Krueger, 1991]. Panayotou [1993] named this inverted U curve the Environmental Kuznets Curve. The proposed name became widely used in the literature.

In accordance with the theoretical assumptions, environmental pressure increases quicker than GDP in the first period of income growth (economic development) (phase 1). In the next stage environmental pressure grows, but its growth rate is slower than economic growth (phase 2). After a certain level of income has been achieved, environmental pressure decreases in spite of rising GDP (phase 3). This is the moment when the "de-linking" of income growth from environmental pressure takes place. If this de-linking is lasting,

environmental pressure declines further. But this de-linking might not be permanent – it might be followed by a stage of "re-linking" (phase 4). In such a case the curve is N-shaped.

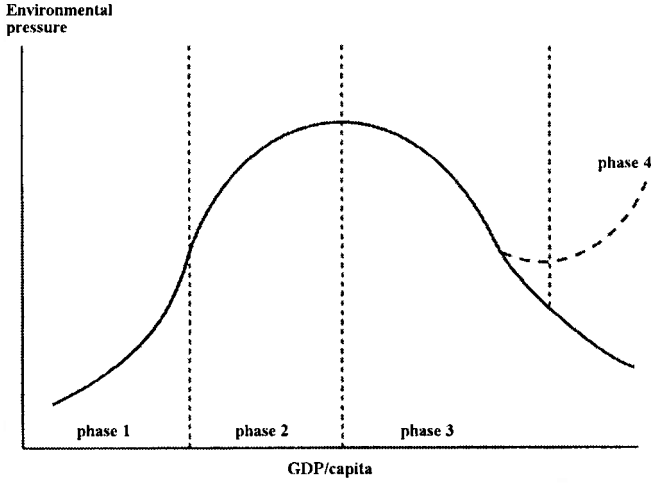


**Fig. 1.** Relationship between income growth and environmental pressure
Source: de Bruyn, Heintz [1999, 658].

## 3. Empirical verification of the EKC

Empirical verification of the EKC has been attempted by a number of economists.[1] De Bruyn and Heintz [1999] present an overview of the results of these studies (Table 1).

For the majority of these measures of environmental pressure no single model of the income–pressure relation was found (Table 1). For instance, in the case of water quality indicators (the amount of faecal coliform, dissolved oxygen) Grossman and Krueger [1995] found an inverted U curve. However, Shafik and Bandyopadhyay [1992], as well as Torras and Boyce [1998], reported various relationships, including an N-shaped curve, a monotonically increasing curve and also a line parallel to the x axis. The only exception is $NO_x$ emissions, where two studies find an EKC [Panayotou, 1993; Selden and Song, 1994]. It is worth noting that for each pollutant at least one study affirms the EKC hypothesis. This occurs most often in the case of air pollutants.

[1] The most popular studies are: Shafik and Bandyopadhyay [1992], Panayotou [1993], Selden and Song [1994], Grossman and Krueger [1995], Holtz-Eakin and Selden [1995], Kaufmann et al. [1998], de Bruyn et al. [1998], Torras and Boyce [1998], List and Gallet [1999], Stern and Common [2001].

**Table 1.** Chosen empirical studies of the relationship between income and environmental pressure

| Authors | $SO_2$ | Particulates | $NO_X$ | $CO_2$ | Faecal coliform | 1/dissolved oxygen* | Deforestation |
|---|---|---|---|---|---|---|---|
| Grossman and Krueger, 1995 | N 4100 13000 concentration | EKC 6200 concentration | | | EKC 8000 | EKC 2700 | |
| Shafik and Bandyopadhyay, 1992 | EKC 3700 concentration | EKC 3300 concentration | | MI | N 1200 11400 | MI | P |
| Panayotou, 1993 | EKC 3000 emissions | EKC 4500 emissions | EKC 5500 emissions | | | | EKC 1200 |
| Selden and Song, 1994 | EKC 10300 emissions | EKC 10300 emissions | EKC 11200 emissions | | | | |
| Torras and Boyce, 1998 | N 3400 14000 concentration | P | | | P | N 5100 19900 | |
| Holtz-Eakin and Selden, 1995 | | | | EKC 35400 | | | |

* Dissolved oxygen is an indicator of environmental quality, not its degradation. Hence, the inverse of dissolved oxygen is used. For this reason the EKC is a U-shaped curve.

*Notes:*

1. The table cells contain: the type of the curve, the value of GDP per capita (USD) at the extreme point (or – in the case of an N curve – extreme points) and the method used for measuring environmental pressure (in the case of atmospheric measurements).

2. Abbreviations: N = N-shaped curve, EKC = inverted U-shaped curve, MI = monotonically increasing curve, P = line parallel to x axis.

Source: adapted from De Bruyn and Heintz [1999, 662].

Estimates of the extreme points, representing the level of GDP above which environmental pressure starts to decrease, differ significantly among various studies. For particulates, Shafik and Bandyopadhyay [1992] estimate the extreme point to be 3300 USD per capita, while Selden and Song [1994] estimate it to be 10300 USD. As for $SO_2$ emissions, Shafik and Bandyopadhyay [1992] indicate that the extreme point is approximately 3700 USD and Grossman and Krueger [1995] – 4100.

## 4. Reasons for the welfare-environmental pressure relation to adopt the shape of the EKC

The literature does not give an unambiguous answer to the question regarding the shape of the welfare-environmental pressure curve or any interpretation of the coefficients estimated. The relation described by the EKC may be explained by [de Bruyn and Heintz, 1999, 665–669]:

– changes in behaviour and consumer preferences: when a country reaches an adequately high standard of living, people value environmental amenities more and more,

– institutional changes: *e.g.*: subsidies or their absence, property rights on natural resources, ecological policy,

– technological and organizational changes: as economic development progresses, capital stock is replaced with new capital – usually of higher efficiency and thus causing lower environmental pressure,

– structural changes: structural changes in the economy – from an agricultural to service economy,

– international reallocation: relocating "dirty" industries to less developed countries, causing a decline in environmental pressure in developed countries and an increase in developing ones.

If the EKC describes changes in environmental pressure during the process of economic growth correctly, growth might be beneficial to the state of the environment. Beckermann [1992, 491] even says that "the strong correlation between incomes and the extent to which environmental protection measures are adopted demonstrates that, in the longer run, the surest way to improve your environment is to become rich."[2] But some point out that drawing such unequivocal conclusions is impossible, since we have no answers to a series of questions concerning the nature of the EKC. It is not clear whether the EKC is valid for all types of environmental pressure or whether it works in the same way for all countries. Neither do we know whether the EKC is fixed or whether it is optimal [de Bruyn and Heintz, 1999, 670].

## 5. The welfare-environmental pressure relationship in transition countries

In order to picture the relation between welfare and environmental pressure in countries going through a period of economic transition, a study was

[2] A similar idea was put forward by I. Gandhi during the conference in Stockholm (1972) – she said: "Poverty is the biggest polluter".

conducted in Poland. The analysis covered the years 1980–2003. In one case (CO2), due to a lack of data, only the period 1988–2003 is considered. The level of welfare is represented by GDP (current prices, per capita, USD). The level of environmental pressure for a specific year was ascribed to the corresponding GDP value. Several components of environmental pressure were analysed: air pollution (emissions of $SO_2$, $NO_x$, $CO_2$, particulates), water (water use, sewage discharges) and the use of geological resources.

As welfare in Poland grew, there was a significant decrease in the economic system's pressure on the atmosphere (Figures 2–4). In the case of three indicators – $SO_2$, $NO_x$ and particulates – growth in GDP per capita was accompanied by a considerable decrease in their emissions. The estimates of the level of GDP per capita maximizing the discharge of these substances' into the air are: for $SO_2$ – 4 830 USD, for $NO_x$ – 4 440 USD and for particulates – 4 202 USD. It should be noted that these levels are similar to the ones shown in Table 1.

Each curve has a negative trend. It may be assumed that these curves are fragments of the EKC, namely the part to the right of the maximum point. Due to a lack of data, it is difficult to determine the shape of the curve at lower levels of GDP per capita.

It is also difficult to establish whether this negative trend is permanent or whether the curves will eventually adopt an N-shape. This seems especially important in the case of $SO_2$ emissions, where two studies [Grossman and Krueger, 1995; Torras and Boyce, 1998] revealed an N-shaped curve representing the welfare-environmental pressure relation. In the first study the extreme points were estimated to be 4 100 GDP and 13 000 GDP per capita, while in the second they were estimated to be – 3 400 and 14 000, respectively.

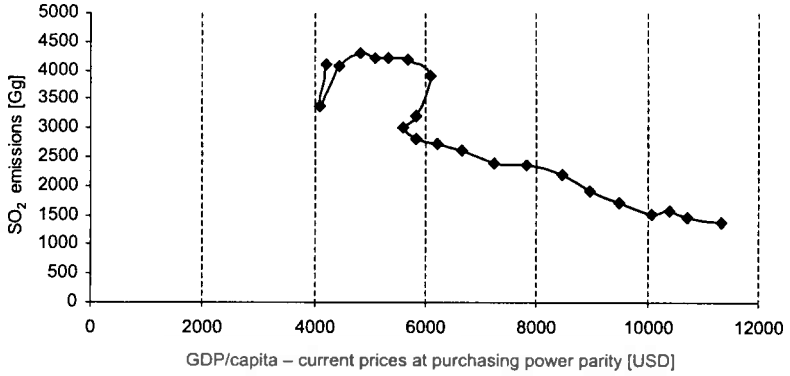


**Fig. 2.** $SO_2$ emissions and per capita income in Poland in the years 1980–2003

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

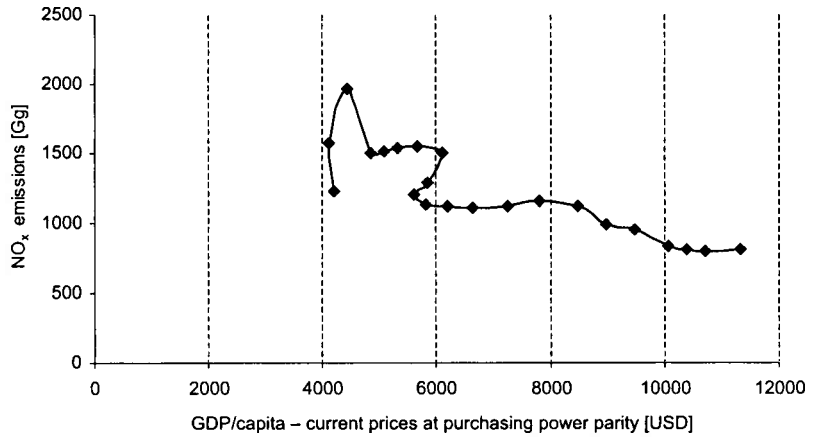


**Fig. 3.** $NO_x$ emissions and per capita income in Poland in the years 1980–2003

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006

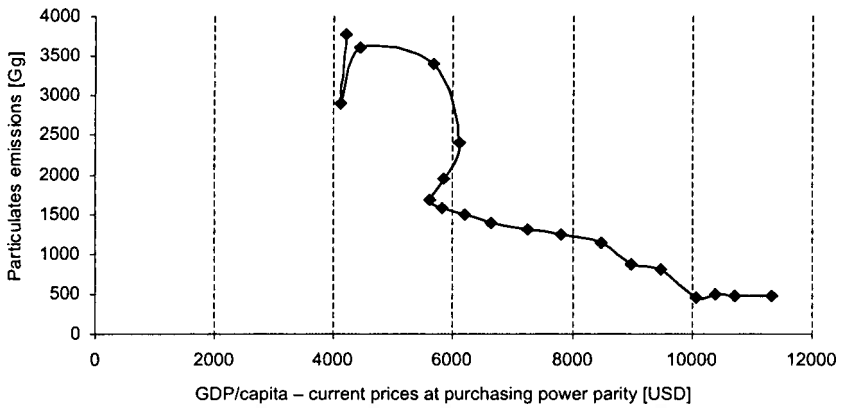


**Fig. 4.** Particulate emissions and per capita income in Poland in the years 1980–2003

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

The EKC curve for $CO_2$ emissions has a totally different shape (Figure 5). As welfare grew, emissions remained at roughly the same level. The resulting curve is parallel to the x axis.

This outcome is quite different from the results of previous studies. Shafik and Bandyopadhyay [1992] found a monotonically increasing curve, while Holtz-Eakin and Selden [1995] argue that this curve has an inverted U-shape, with an maximum point at 35 400 USD of GDP per capita.

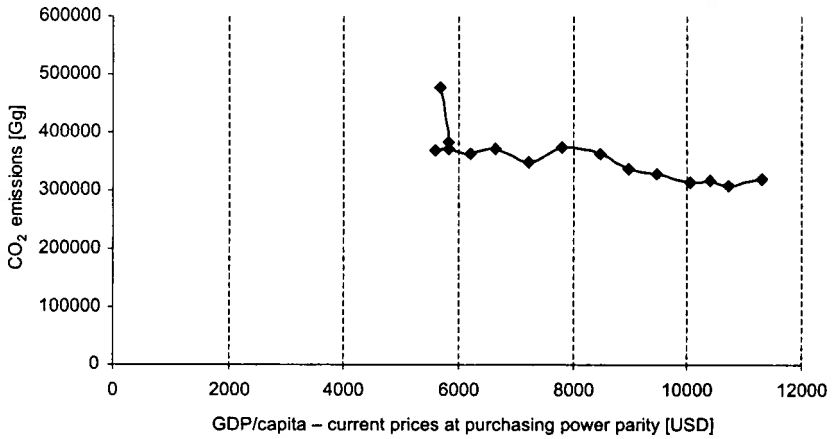


**Fig. 5.** $CO_2$ emissions and per capita income in Poland in the years 1980–2003

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

On one hand, it should be presumed that too low a level of GDP does not allow us to determine the real character of the welfare-environmental pressure relation for Poland. Not until this level rises can the form of the curve indicate whether this relation is monotonic increasing or has an inverted U-shape. But on the other hand, actions undertaken within ecological policies, both on a global and local scale, make one rather expect a decline in $CO_2$ emissions.

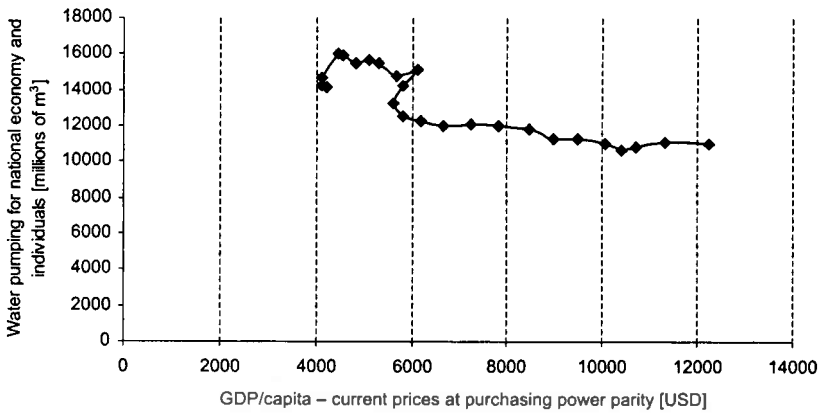


**Fig. 6.** Water use and per capita income in Poland in the years 1980–2004

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

In this case if GDP continued to grow, it would eventually lead to a negative trend in the level of $CO_2$ emissions.

The situation regarding water use is a bit different (Figures 6–7). The considerable decline in air pollution accompanying welfare growth was not observed for water use. The highest level of water use was recorded at 5 081 USD of GDP per capita. When this value is exceeded, water use starts to decrease

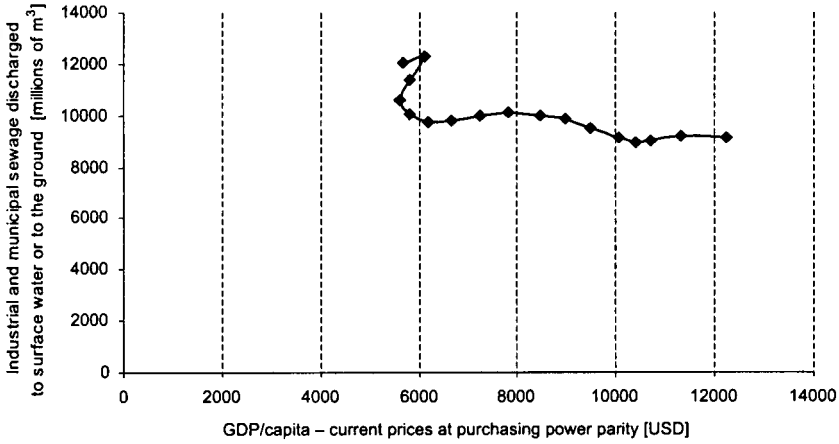


**Fig. 7.** Sewage discharges and per capita income in Poland in the years 1980–2004

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

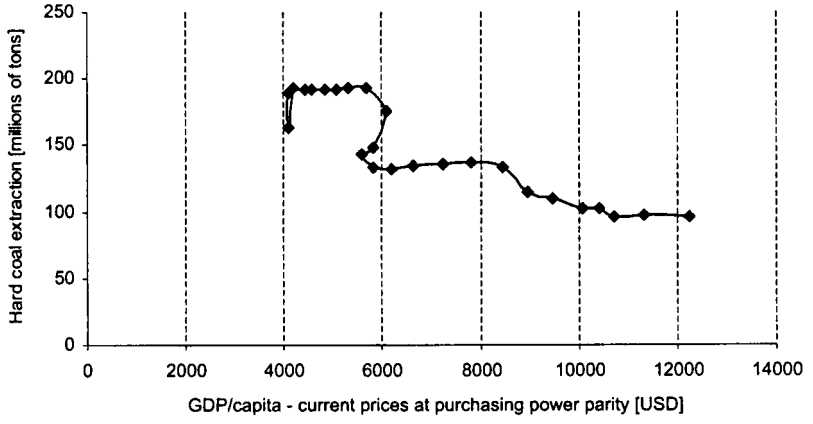


**Fig. 8.** Hard coal extraction and per capita income in Poland in the years 1980–2004

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

slowly. Above about 10000 USD of GDP per capita water use remains at a relatively constant level, despite further growth in the domestic product (Figure 6).

The relation between welfare and environmental pressure is similar in the case of sewage discharges. After reaching a maximum at 6102 USD of GDP per capita, pressure started to decline, even though domestic product was then falling. The decrease in pressure is not rapid and it stabilized when GDP per

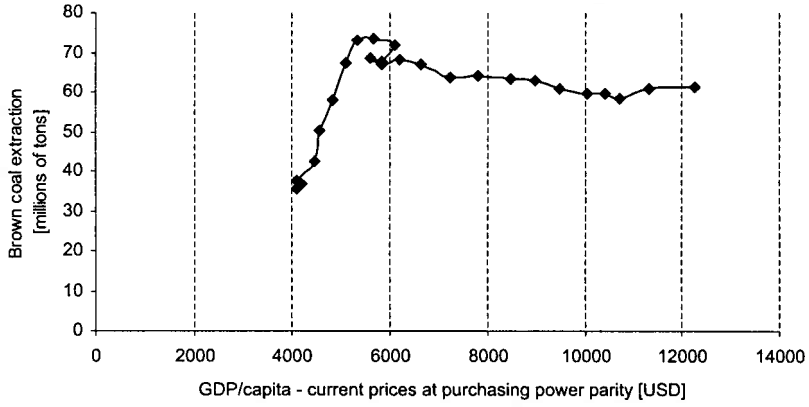


**Fig. 9.** Brown coal extraction and per capita income in Poland in the years 1980–2004

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

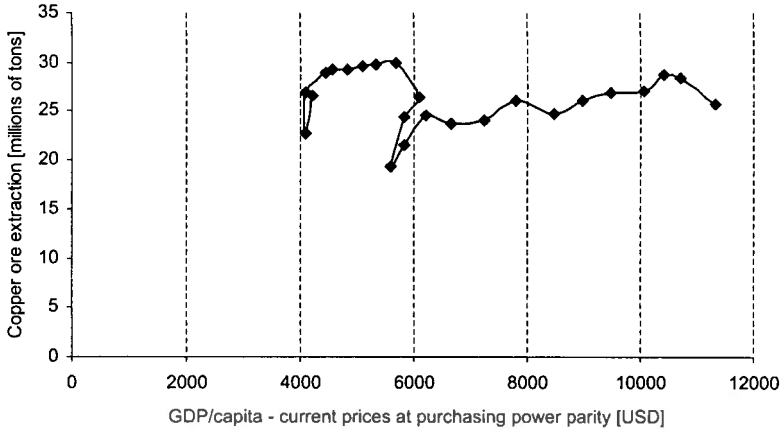


**Fig. 10.** Extraction of copper ore and per capita income in Poland in the years 1980–2004

Source: author's own elaboration based on statistical data from Econstats, The World Factbook 2000–2006, internet database of yearly emissions to air and statistical yearbooks by Central Statistical Office of Poland for 1989–2006.

capita reached about 6 500 USD. After this the curve is parallel to the x axis (Figure 7).

Exploitation of minerals to produce energy seems subject to the EKC rule. In the cases of both hard and brown coal, the maximum level of extraction was recorded at about 4 500–5 500 USD of GDP per capita. Further economic growth brought a decline in the exploitation of these minerals (Figures 8–9).

However, the rule described above does not govern the exploitation of copper ore. It seems that in this case it is difficult to find the relationship between the level of exploitation and GDP per capita, at least over the range of values for domestic product observed (Figure 10).

## 6. Conclusions

This study of the welfare-environmental pressure relationship in a transition economy covered only chosen indicators. Some of them seem to confirm the EKC hypothesis, others do not give any evidence for it.

A decrease in environmental pressure accompanying growth in GDP per capita can be seen for indicators related to energy generation: emissions of sulphur dioxide, nitrogen oxides, and particulates into the air, as well as extraction of hard and brown coal. It seems that this might be explained by structural changes in the economy. As the process of transition advances, the character of the economy gradually changes. The economic importance of industry and agriculture diminishes and the importance of the service sector grows, which is less energy-intensive and causes lower environmental pressure.

Technological and organizational changes also seem significant. New technologies and related market and administrative demands might considerably contribute to the decrease in environmental pressure accompanying GDP growth. Similarly, new organizational solutions may cause a significant decline in the economy's pressure on the environment. A relatively high level of investment in environmental protection in Poland from 1990 to 2003 and the substantial popularity of environmental management systems seem to be reasons for the decrease in environmental pressure accompanying increasing welfare.

It seems that during the transition process the dynamics of these two processes intensifies: the rates of change in welfare and environmental pressure are high. This makes the characteristics of the relation between these processes easier to spot than in stabilized economies. But on the other hand, it is impossible to draw any conclusions concerning changes in environmental pressure for the range of values of GDP per capita which have not yet been observed in transition countries. This significantly limits the scope of the analysis which may be carried out. For example, a previous study shows an EKC maximum point for CO2 at 35 400 USD per capita, while the maximum

level of GDP in Poland reached to date is slightly over 12000 USD. Results for indicators whose maximum points were at lower levels of GDP are also uncertain. It is hard to verify whether the decrease in environmental pressure accompanying welfare growth is permanent or whether at higher, currently unattainable, GDP levels it might rise again.

Considering the diversity of results from empirical studies, it should be assumed that for now the validity of the EKC remains an unverified hypothesis. The inverted U-type relation between income and environmental pressure should be treated as a simplified description of the phenomenon, which requires further research and evidence [de Bruyn and Heintz, 1999, 655]. The analyses discussed above cover only one transition economy. A more comprehensive and deeper insight might result from a study covering a wider group of countries going through the process of economic transition and using a greater number of indicators of environmental pressure.

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