ECONOMIC GROWTH AND NO_X EMISSIONS IN THE POST-COMMUNIST COUNTRY

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ABSTRACT

Due to the newly available consistent historical dataset, this paper will contribute to the debate on the link between economic growth and the environmental burden in case of the post-communist country of the Czech Republic. More specifically, the analysis will test environmental Kuznets curve (EKC) for NO_X emissions between 1980 and 2015. However, modelling on long-term data did only prove decreasing phase of EKC but did not show increasing phase. Therefore, it can be assumed that breaking point occurred earlier than in the monitored period. However, political and economic transformation processes in the 1990s had significant impact on the decreasing burden on the environment in terms of NO_X.

Keywords: *Economic Development, Environmental Burden, Environmental Kuznets Curve, Decoupling, NO_X Emissions*

1. INTRODUCTION

Rapid growth of global population and economic growth are phenomena that are closely connected to serious challenges human civilization faces nowadays such as overexploitation, climate change, pollution, or biodiversity loss (UNEP, 2011). Population growth along with the increasing quality of life put pressure on the environment. Especially with increased demands on material, energy sources, but also waste production and greater demand on food production. Economic growth has resulted in significant growth in energy needs (Van Aardenne, Carmichael, Levy, Streets & Hordijk, 1999). According to data of World Bank (2014), electric power consumption (kWh per capita) increased by 160 % between 1971 and 2014. Although the electricity production from renewable sources has been rapidly growing, especially from the turn of the millennium, electricity production from oil, gas and coal sources has grown by more than 6 % in the same time-period. In terms of the Czech Republic, since the establishment of the independent Czech Republic in 1993, electricity consumption (kWh per capita) has increased by almost 25 %. However, fossil fuel energy consumption has been constantly decreasing (World Bank, 2014).

Globally, increasing energy demand will result in a large NO_X emissions increase. Abbreviation NO_X usually relates to nitrogen monoxide NO and nitrogen dioxide NO_2 and thus will be understood in this work. Man-made NO_X emissions are produced in processes such in power plants, motor vehicles and industrial and domestic combustion processes (APIS, 2015). NO_X emissions have many important health but also environmental impacts such as photochemical smog, acid rain, tropospheric ozone, ozone layer depletion and even global warming caused by N_2O (Carslaw, Beeweers, Tate, Wetmoreland & Williams, 2011; Skalka, Miller, Ledakowicz, 2010). However, NO_X emissions represent significant (but not the only) indicator of environmental burden of human activities.

Interest in the relationship between economic growth and environmental burden has been growing mainly since 1990s. Since that time, this topic became a central subject of many studies. One of the hypothesis claim that in the early stages of economic development, environmental burden is growing faster than revenues, while at a later stage of economic development, environmental burden decreases more slowly than GDP growth (Dinda, 2004; Lešáková, Dobeš, 2018). This hypothesis is called Environmental Kuznets curve (EKC). The aim of this work is to validate EKC for NO_X as the indicator of environmental burden for the Czech Republic as the post-communist country. As in many other post-communist countries, authors analysing economic, environmental and social indicators in the Czech Republic struggle with insufficient length of time series of these type of indicators. Moreover, this problem is compounded by the fact that after the fall of the regime in 1989, the Czech and Slovak Federative Republic was split into Czech Republic and Slovakia in 1993. To monitor long-term phenomena before 1989, estimates and modelling are required. Due to newly available historical economic and environmental data for the Czech Republic, this paper offers unique long-term relationship analysis between GDP (economic indicator) and NO_X emissions (environmental burden indicator).

This paper follows previous analysis (Lešáková, Dobeš, 2018) of validity of EKC for CO_2 emissions in the Czech Republic and compares them in Conclusion part of the paper.

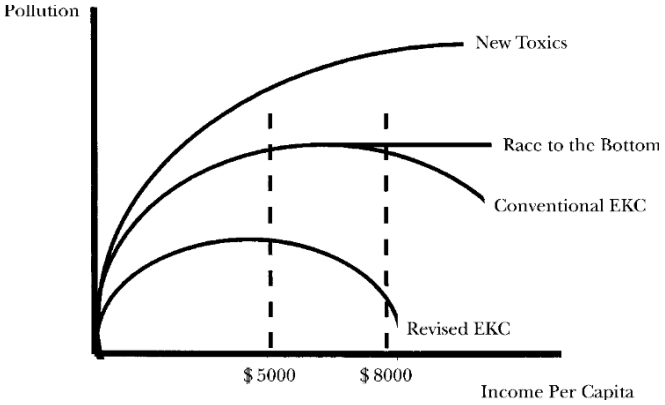
2. ENVIRONMENTAL KUZNETS CURVE

The concept of EKC was introduced by authors Grossman and Krueger in early 1990s. In their work (Grossman, Krueger, 1991), these authors described nonlinear inverted u-shaped relationship between income and pollution. According to some authors (Arrow, 1995; Chen, Huang, & Lin, 2019; Dinda, 2004; Dasgupta, 2002) in the first phase of industrialization, along with rising income, there is a sharp increase in environmental pollution. These authors describe in their works following characteristics of the early stage of economic growth:

- Economic development is accelerated by intensification of agriculture and the depletion of natural resources.
- Environmental awareness is low or negligible in an early stage of economic development.
- Environmentally friendly technologies are not available.
- In this phase, people prefer jobs and incomes rather than clean air and water at this time.
- People are basically too poor to pay for improving the environment.
- Environmental regulation is weak at this point.

Environmental burden continues to grow until earnings rise to a certain level (a breakpoint) and second phase occur. As the incomes grows, environmental awareness increases, regulatory instruments become more efficient. Investments into technological development reduces pressure on the environment. People pay more attention to the air and water quality and environment in general.

If we wanted to display the previous description graphically, it could be described as converted u-shape curve as can be seen in the following figure.



However, EKC hypothesis validity has not been resolved. From the first definition of this hypothesis in 1992, this concept has been extensively studied. EKC was tested for different greenhouse gases responsible for global warming such as CO_2, SO_X and NO_X (Miah, Masum, Koike, 2010). Many authors have attempted to confirm or refuse the hypothesis by its practical application in various conditions and regions. In study of Sinha, Bhat (2017), n-shaped EKC for NO_X was observed in India. Same conclusion is provided by study from Italy (Mazzanti, Montini, 2007). On the other hand, in other studies (Caviglia-Harris, Chambers, Kahn, 2009; Busa, 2013) authors doubt that countries can "grow up" from their environmental problems.

However, there is persistent uncertainty about EKC validity. As Yang, Zhang, Xue, Ma, Chen & Lu (2018) claim, existence of environmental EKC is not enough to understand how economic growth induced environmental pollution. This paper therefore contribute to this debate on the dependence of GDP and NO_X emissions.

3. RESEARCH METHODOLOGY

3.1. Data Collection

In the Czech Republic, same as in any other post-communist country, qualified users face a problem of insufficient data in long time series. It is problematic to ensure data before 1990. Therefore, they usually rely on estimates in their analysis. In this paper, the source of economic data (GDP) until 1989 comes from the articles (Sixta, Šimková, Vltavská & Zeman, 2016; Vltavská, Sixta & Šimková 2018) and the source of data on GDP since 1990 comes from the Czech Statistical Office (CSO, 2018). This GDP data is methodologically comparable and both respect ESA 2010 standard.

Environmental indicator is represented by air quality indicator – nitrogen oxides emissions. NO_X was chosen as the environmental pollution indicator.

The input data table is listed below.

Table 1: Input Data (Source: own, based on CSO; 2018; EMEP, 2018; Sixta, Šimková, Vltavská, Zeman, 2016; Vltavská, Sixta & Šimková, 2018)

Year	GDP per capita (CZK, current prices)	GDP per capita (CZK, prices of 2010)	NOx per capita (kg)
1980	46,540	229,785	91
1981	45,354	229,755	79
1982	47,958	226,538	79
1983	49,279	229,981	80
1984	51,403	236,206	82
1985	52,853	240,323	80
1986	54,408	246,774	80
1987	55,536	253,226	79
1988	56,932	258,564	83
1989	59,019	261,669	89
1990	65,065	263,877	52
1991	84,384	239,585	51
1992	94,642	233,966	48
1993	116,265	236,746	44
1994	132,588	242,142	36
1995	153,565	257,032	36
1996	176,275	268,286	35
1997	190,100	266,994	34

Year	GDP per capita (CZK, current prices)	GDP per capita (CZK, prices of 2010)	NOx per capita (kg)
1998	208,490	266,341	31
1999	218,075	270,477	30
2000	231,627	282,300	28
2001	251,199	291,884	29
2002	262,886	297,388	28
2003	275,483	308,077	28
2004	300,036	323,026	28
2005	319,025	343,217	27
2006	342,156	365,577	26
2007	372,007	383,963	26
2008	385,833	390,217	24
2009	374,628	369,288	22
2010	376,759	376,759	21
2011	384,289	384,208	20
2012	386,317	380,678	18
2013	389,900	378,785	17
2014	409,870	388,550	16
2015	435,911	408,474	16

3.2. Decoupling

As in the previous research (Lešáková, Dobeš, 2018) with validating EKC for CO_2 emissions, this paper is based on the same methodology.

A Decoupling Index (DI) is used as a tool to monitor the time changes between environmental pressure and economic growth. This index was presented by OECD (2002) for the first time. Decoupling represents a process of disconnecting link between economic growth and environmental burden.

Decoupling Index is described in the following formula.

$$DI = 1 - \frac{\frac{E_t}{Y_t}}{\frac{E_0}{Y_0}} = 1 - \frac{EP_t}{EP_0} \quad (1)$$

where *DI* represents the decoupling index, *0* and *t* represent the starting and ending year of the reference period, *E* is the value of the environmental pressure indicator, *Y* is the value of the economic performance indicator. *EP* represents *E* and *Y* ratio, *EP = E / Y*, which represents the total environmental pressure.

As a result, one of these three situations can occur:

Table 2: Decoupling results interpretations, source: own, based on Yu et al.(2017), OECD (2002)

	Decoupling index (DI)	Conditions		Description
Absolute decoupling	DI = (0;1>	Yt > Y0 Et ≤ E0		The economy is growing while environmental pressure does not grow
Relative decoupling	DI = (0;1>	Yt > Y0 Et > E0	Yt/Y0 > Et/E0	Economics and environmental pressure are on the rise, but the economy has a faster growth rate
Coupling	DI < 0	Yt > Y0 Et > E0	Yt/Y0 < Et/E0	Economics and environmental pressures are on the rise, but the economy has a slower growth rate

As shown in the table above, the most desirable state is absolute decoupling, when the economy is growing and the pressure on the environment is decreasing. On the other hand, coupling, which represents the opposite and unwanted state, is a situation where the economy and the pressure on the environment are growing, but the burden of the environment is growing faster than the economy. The third possible result is represented by relative decoupling. This occurs when both the economy and the burden on the environment grow. However, the growth rate of the economy is faster in this case than the growth rate of the burden (Lešáková, Dobeš, 2018).

3.3. Z-score

For data standardization, standard deviation was applied.

Because the variables in different units appear in the empirical part of the research (e.g. GDP/capita is expressed in crowns and NO_X/capita in kilograms). In order to compare these variables, it is desirable to convert them to the same scale by standardization. In this paper, standard deviation method was applied.

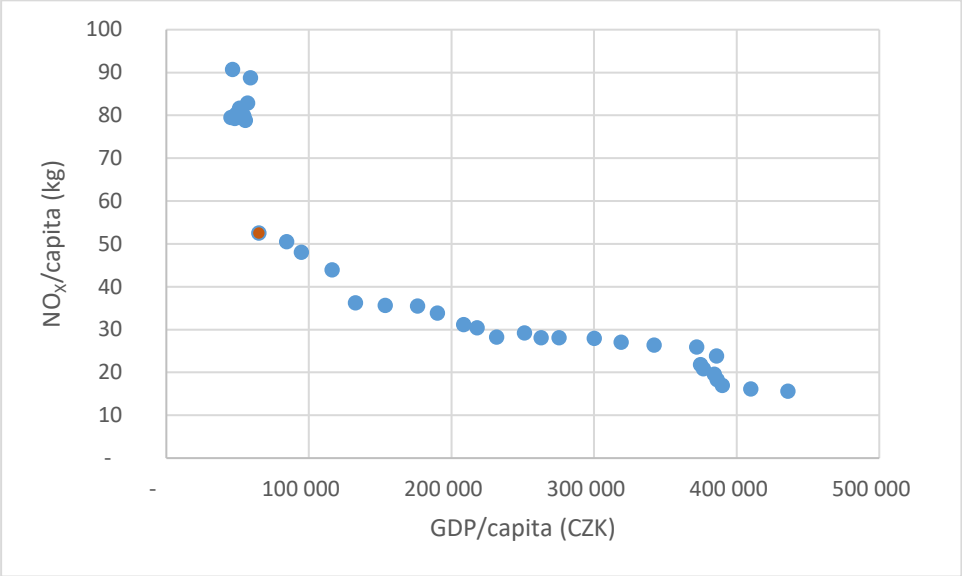
The simplified formula can be expressed as:

$$z=x-\mu\sigma \tag{2}$$

where x represents the value of the monitored indicator, μ represents the mean of the values, σ represents the standard deviation.

4. RESULTS

4.1. Testing EKC for NO_X



Same as in the previous research for CO_2 (Lešáková, Dobeš, 2018), it is not clear from the graph whether the EKC model for NO_X is valid in the Czech Republic. Mainly because the growing phase of this curve is not clear. However, it is evident that there was a break in the late 1980s and that the curve continues to decline (year 1990 is shown in red colour). The transformation processes in economy after 1989 accelerated the decline of NO_X emissions.

To provide deeper analysis, decoupling analysis between 1980 and 2015 will be investigated by using input data. By assigning input data to the decoupling formula we obtain the following equations:

$$\mathbf{DI} = \mathbf{1} - \frac{\frac{\mathbf{16_{2015}}}{\mathbf{435,911_{2015}}}}{\frac{\mathbf{91_{1980}}}{\mathbf{46,54_{1980}}}} = \mathbf{1} - \frac{\mathbf{0,037_{2015}}}{\mathbf{1,9_{1980}}} \tag{2}$$

$$DI = 0{,}98 \tag{3}$$

This result, when *DI> 0*, tells us that in the observed period, when the starting period is 1980 and the final period is 2015, absolute decoupling actually occurs.

Following graph represents decoupling graph where normalized data is used. This graph shows clear trends. NO_X emission per capita has decreasing trend and GDP per capita has increasing trend. From a certain point in time, the economy produces increasing value with less environmental burden. It is evident that this break point happened in 1997. However, significant NO_X decrease has been ongoing since the late 80´s. It is due to combination of the change in

vehicle sheet, as well as a decrease in energy emission and industrial sources. Therefore, we can assume that political and economic transformation processes in the 1990s had significant impact on the decreasing burden on the environment in terms of NO_X. However, intersection of economic performance curve and environmental burden curve occur eight years after the political transformation. In comparison with previous research for CO_2, this intersection for NO_X appears ten years after the CO_2 intersection.

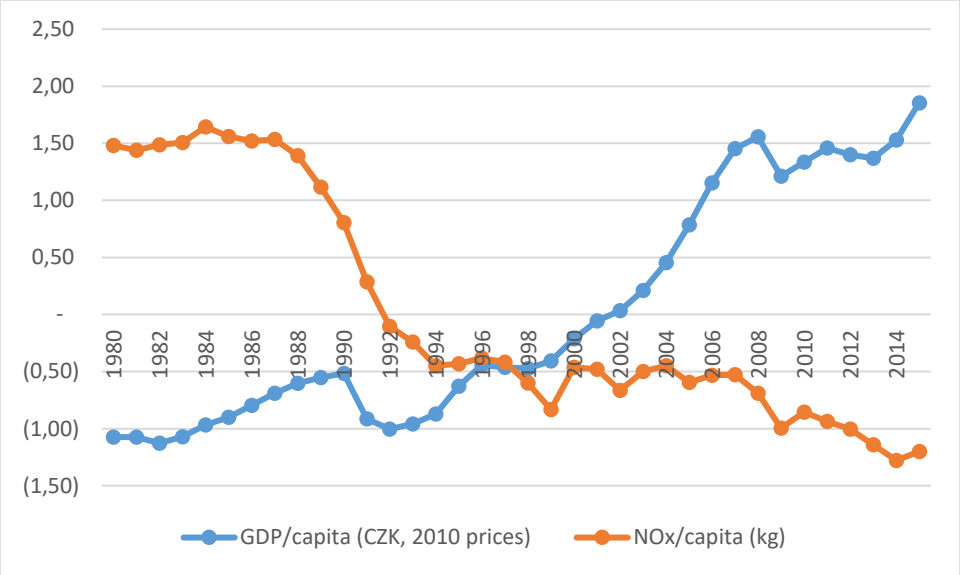


Figure 1 Decoupling of z-score values (Source: based on own calculations)

CONCLUSION

Population growth along with the increasing quality of life put pressure on the environment. Especially with increased demands on material, energy sources, but also waste production and greater demand on food production. Due to newly available historical economic and environmental data for the Czech Republic, this paper offers unique long-term relationship analysis between GDP (economic indicator) and NO_X emissions (environmental burden indicator). However, it is not clear from the graph whether the EKC model for NO_X is valid in the Czech Republic. Mainly because the growing phase of this curve is not clear.

The decoupling method was also used to fulfil the objective of the paper. The analysis shows that the economy produces increasing value with less environmental burden effect over the reporting period. In comparison with previous research for CO_2, this intersection of NO_X curve and GDP curve appears ten years after the CO_2 curve intersection with GDP curve. For further research, it would be interesting to determine the main drivers to predict curves intersection in developing countries that deal with severe environmental burden.

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