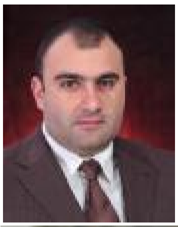
EMISSION MODELS OF SULFUR AND NITROGEN OXIDES AND EXPENDITURES OF ENVIRONMENTAL PROTECTION IN THE IN EUROPEAN UNION



VLADIMIROV Lyubomir
lvvladimirov@uni-use.bg

University of Ruse, 8 Studentska, Ruse 7017, Bulgaria

KOVACHEV Nikolai
nkovachev@uni-use.bg

University of Ruse, 8 Studentska, Ruse 7017, Bulgaria

Abstract: The purpose is to determine the impact of the expenditures for environmental protection of the emissions of sulfur and nitrogen oxides in the European Union. To achieve it there are to solve three tasks. Defining of the five indicators of the expenditures of environmental protection is made in the first task. The second task is a data base using official information sources creation. Numerical models and dependencies of the emissions of sulfur and nitrogen oxides and the cost of environmental protection for a ten year period are obtained.

Key words: sulfur and nitrogen oxides, expenditures, environment.

Introduction. The studies on the financing of the environmental protection show that the dependencies of the expenditures in the European Union have not been analyzed in detail. Incpmlete information is provided by the Statistical Office Eurostat and the national statistical institutes of the Member States. The dependencies of pollutant emissions and expenditures for the protection of the environment as a function of time have not determined.

The objective in the paper is to determine the impact of the expenditures for environmental protection on the emissions of sulfur and nitrogen oxides.

Research results. To solve the problem the following tasks are to complete:

1. Defining the indicators of the expenditures for environmental protection .
2. Creating a database .
3. Presentation of the mathematical models and dependencies of the emissions of sulfur and nitrogen oxides from the expenditures as a function of time.

Five basic indicators are used.

First indicator is Resource productivity RP (Euro per Kilogram).

Resource productivity is GDP divided by domestic material consumption (DMC). DMC measures the total amount of materials directly used by an economy. It is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports. It is important to note that the term "consumption" as used in DMC denotes apparent consumption and not final consumption. DMC does not include upstream flows related to imports and exports of raw materials and products originating outside of the focal economy. When examining resource productivity trends over time in a single geographic region, the GDP that should be used is in units of Euros in chain-linked volumes to the reference year 2005 at 2005 exchange rates.

If comparisons of resource productivity between countries are made then the GDP in purchasing power standards should be used and not the chain-linked volume GDP figures.

Resource productivity data of EU countries are given in Figure 1. It covers three data held on the Balkan Peninsula and prominent economically countries - Germany, France, Italy, United Kingdom and Sweden.

The indicator Domestic Material Consumption (DMC) is defined as the total amount of material directly used in an economy. DMC equals Direct Material Input (DMI) minus exports. DMI measures the direct input of materials for the use in the economy. DMI equals Domestic Extraction (DE) plus imports.

Environmental protection expenditure is the money spent on all purposeful activities directly aimed at the prevention, reduction and elimination of pollution or any other degradation of the environment. It includes both investments and current expenditure.

Environmental protection expenditure by the public sector Epe_{ps} (% of GDP) are presented at fig.2. Environmental investment by the public sector (% of GDP) is all outlays in a given year for machinery, equipment and land used for environmental protection purposes – fig.3. Environmental protection expenditure by industry Epeind is in % of GDP. Environmental expenditure means how much has been spent to protect the environment. It includes both investments and current expenditure. The industry includes mining and quarrying, manufacturing and energy and water supply industry (NACE C, D, E excluding recycling part of NACE DN) .

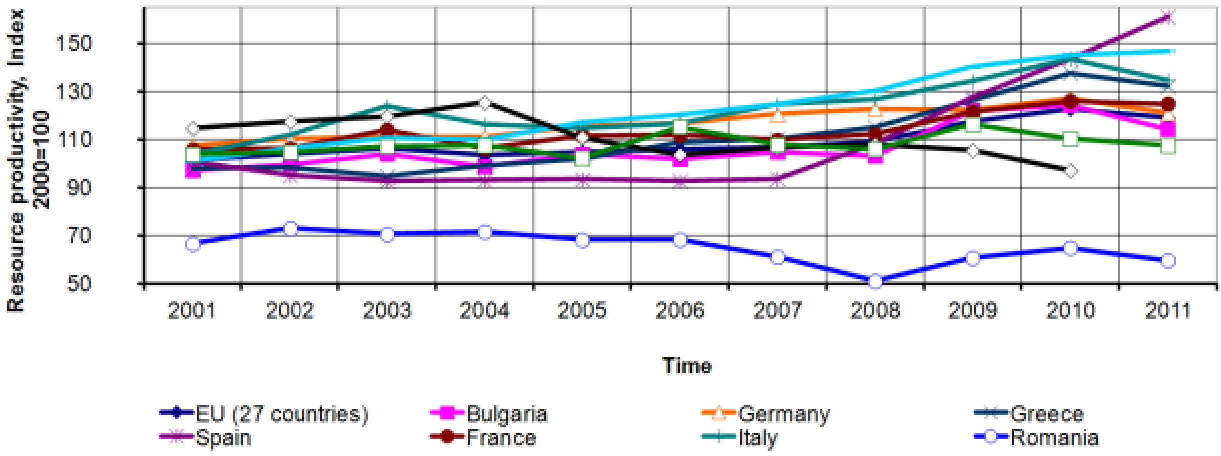


Fig.1. Series of Resource productivity

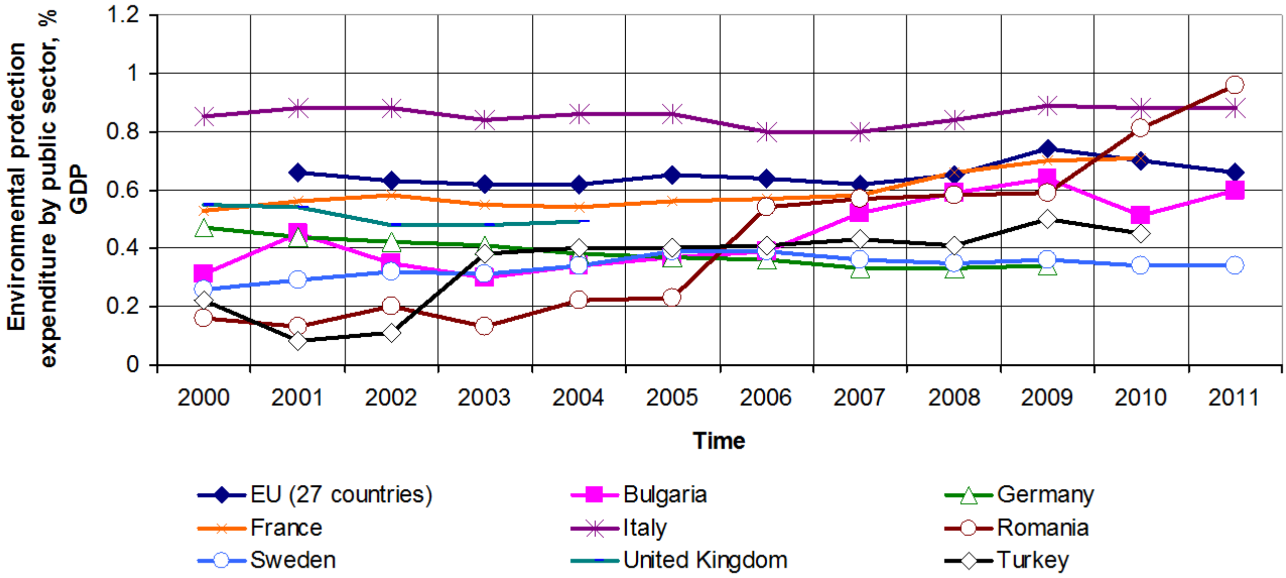


Fig.2. Series of Environmental protection expenditure by the public sector

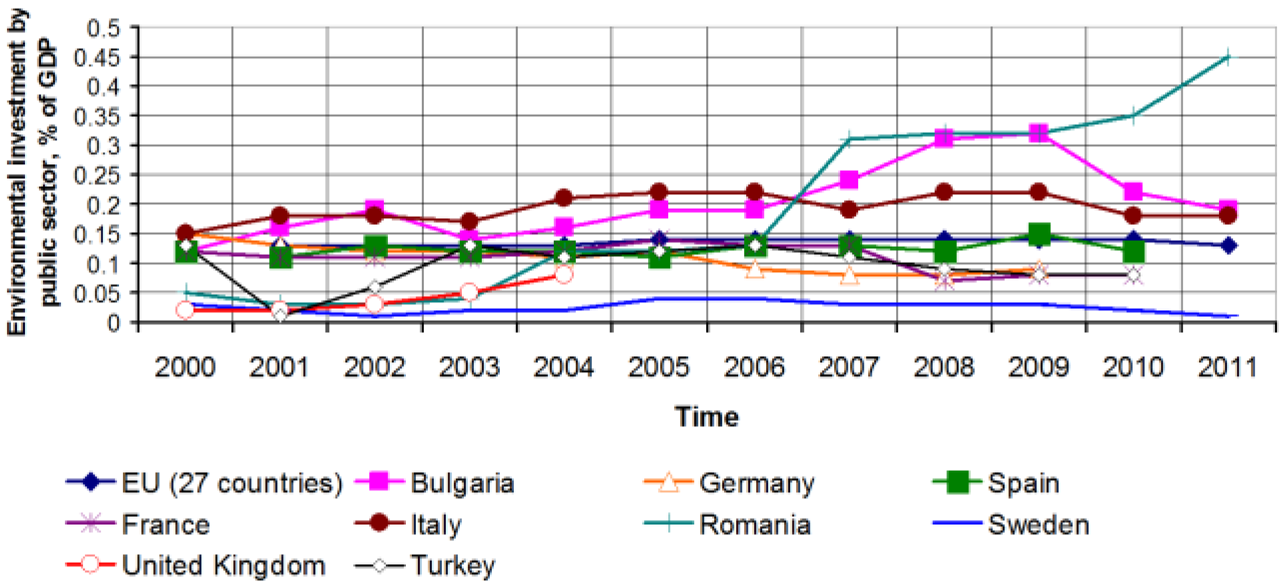


Fig.3. Series of Environmental investment by the public sector

Environmental investment by industry Einin (% of GDP) is all outlays in a given year for machinery, equipment and land used for environmental protection purposes.

An important point is that the industry, according to the classifications of the Statistical Office Eurostat, unites the extraction of materials in mines and quarries, factory production , energy and water supply. The economic activities classification NACE Rev.2, areas C, D, E, including recycling were taken into account.

Current environmental expenditure by the public sector is payments to keep environmental departments running, staff costs and other costs for daily activities within the domain of environment in % of GDP (fig.4).

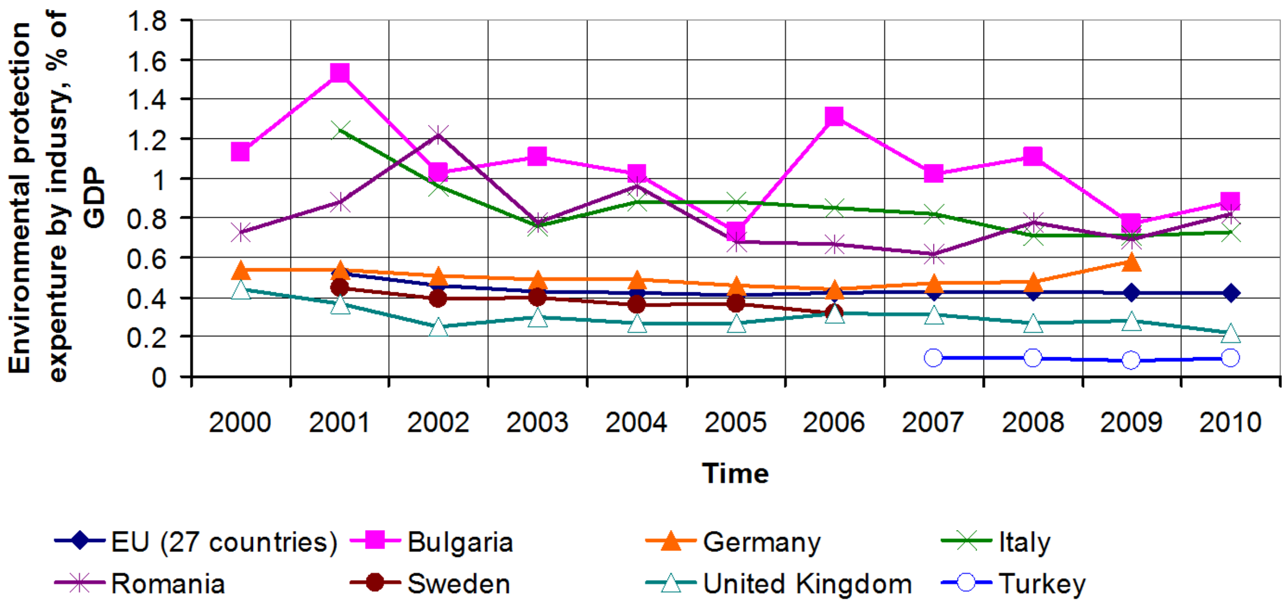


Fig.4. Series of Environmental protection expenditure by industry

Current expenditure for environmental protection includes daily operating activities aiming at the prevention or reduction of pollution. It includes for example waste management, expenditure for staff working on environmental issues and materials for environmental protection.

Current environmental protection expenditure by industry $CEpe_{ind}$ is in % of GDP.

The relationships between the emissions of sulfur and nitrogen oxides from and expenditures in the European Union for the period from year 2000 to 2011 were set. Regression models of the emissions of pollutants studied were derived.

Figures 1-5 illustrate the time series of indicators for that period. Trends are clear.

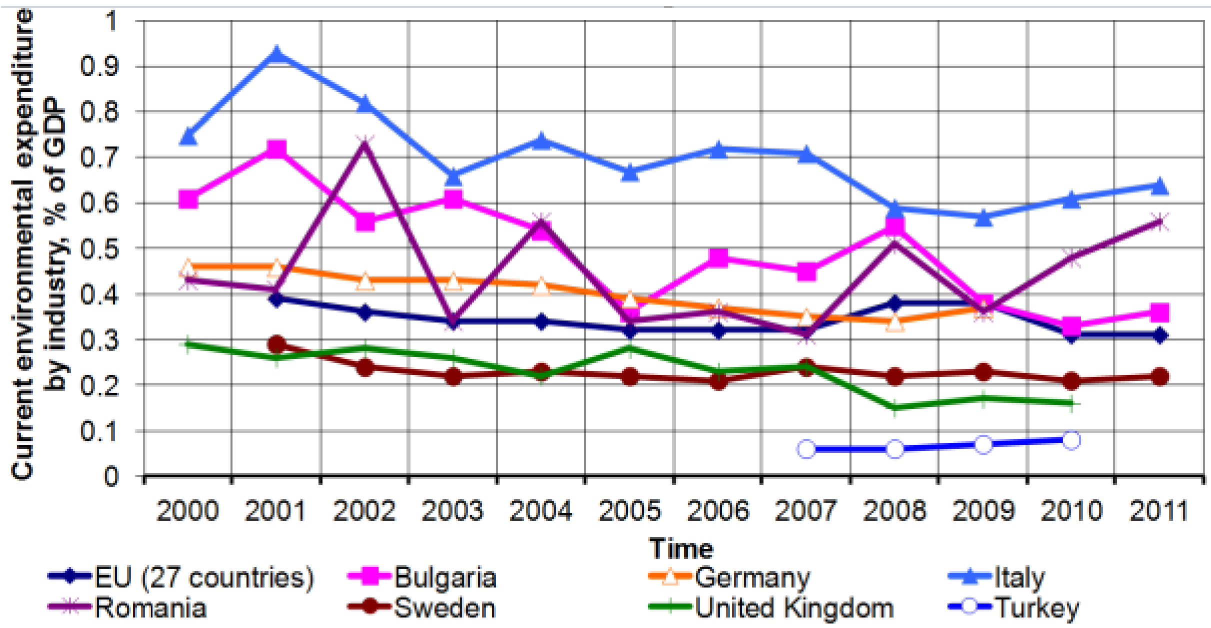


Fig. 5. Series of Current environmental protection expenditure by industry

Analysis of the Resource productivity (Figure 1) shows a relatively small increase for the last three years. The increment is seen significantly in Spain. It has a significantly smaller value in Romania. UK does not publish information on this indicator.

Environmental protection expenditure by the public sector (Figure 2) in Italy are the greatest value. Similar are the values for the other countries. Unlike previous indicator in Romania has suffered the most intensive growth here. After the year 2006 an increment is established in Bulgaria.

Environmental investment by the public sector (Figure 3) is an indicator that is amended in an analogous manner to the indicator Environmental protection expenditure by the public sector. A similar trend is shown for Romania, while in Bulgaria over the past two years it indicatea relatively low values. Although this fact if is above the average values for the European Union.

Environmental protection expenditure by industry (% of GDP) in Bulgaria are greatest - Figure 4, including the comparison with Romania and Italy, which are of a similar nature . Compared to the average expenditures of the European Union in our country the are almost doubled. Most levels are small in the UK.

Current environmental protection expenditure by industry (Fig. 5) in Bulgaria are above the averaged values within the EU. They are comparable with the expenditures in Germany and Romania. In Italy this indicator is much higher than in the other countries. The lowest levels of expenditures are seen in Sweden and the United Kingdom.

The sulfur oxides presented maximums at the beginning and the end of the study period. This is for small and large Resource productivity. Lower values can be explained by the inefficiency of the environment. The big issues are probably due to the anticipation of the use of raw materials and means of protection against the environment.

Trends in nitrogen oxides were explained by the relatively limited environmental expenditures that were made at the beginning of the reference period. It should however be noted that these annual expenditures are not significantly different.

The expenditures for environmental protection in the public sector of the European Union were changed in a strongly visible series: 2001 year - 0.66%, year 2002 - 0.63%, year 2003 - 0.62%, year 2004 - 0.62%, year 2005 - 0.65%, year 2006 - 0.64%, year 2007 - 0.62%, year 2008 - 0.65%, year 2009 - 0.74%, year 2010 - 0.7%, year 2011 - 0.66% of gross domestic product.

The analysis of these data shows that during the period from year 2002 to year 2008, it is settled relatively low expenditures. Higher values were acquired over the years by the end of the period, and particularly in 2009 and 2011,

Sulfur oxides and nitrogen oxides decreased at the end of the period from year 2000 to year 2011 despite a marked limited funding for environmental protection in the public sector. It is difficult to explain the effect, as there is no data on the type and methods of equipment to prevent, limit or reduce the emissions.

Environmental investments in the industry are expenditures for equipment for environmental protection, as well as land use. The distribution is as follows: year 2001 - 0.133, year 2002 - 0.137, year 2003 - 0.131, year 2004 - 0.136, year 2005 - 0.142, year 2006 0.14, year 2007 - 0144, year 2008 – 0141, year 2009 - 0.145, year 2010 - 0.143, year 2011 - 0.131% of the gross domestic product.

In the industrial sector investments in approximately the same: year 2001 - 0.14, year 2002 -0.12, year 2003 -0.09, year 2004 - 0.08, year 2005 -0.16, year 2006 -0.15, year 2007 -0.11, year 2008 -0.13, year 2009 -0.12, year 2010 -0.11, year 2011 - 0.12 of the gross domestic product.

Related dependencies are seen at the emissions of sulfur and nitrogen oxides .

At nitrous oxide it is seen a clear downward trend as a function of time.

The sulfur oxides established more unexplained changes. This is for example the the relationship for the emissions with two maximums - in small and large expenditures for environmental protection. This will include day to day running expenditures for preventing and reducing the air pollution .

It was found difficult to explain pattern. The maximum emission is at the average investment in the initial phase of the reference period.

It is inverse that the increase in the emissions of sulfur oxides, depending on the total expenditures. These changes can be explained most likely at a large database. For example, for 20 years of observations, but at this stage the European statistical office does not have enough data.

Moreover, the statistical institutions of the Member States shall calculate emissions for different methodologies. This also affected the reliability of emerging trends.

However, this is the first attempt for insight into this type of data and display the authentic relationships of the emissions as a function of the total and current expenditures for environmental protection, investment in machinery in the public and industrial sector.

By processing the information with the software Statistika 8.0 the following numerical models of sulfur and nitrogen oxides as a function of time T and the expenditures for environmental protection were acquired:

1) Resource productivity RP (Euro per Kilogram):

$Emission_{SOx}=1.4967E^8+7.308E^6T-2.1477E^8RP+81496.765T^2-5.9038E^6T.RP+8.3462E^7 RP^2$;

$Emission_{NOx}=-1.0816E^7-5.2873E^6T+5.9393E^7RP-1.3218E5T^2+4.4095E^6T.RP-3.0377E^7 RP^2$.

2) Environmental protection expenditure by the public sector Epe_{ps} (% of GDP):

$Emission_{SOx}=3.0725E^7+2.3905E6T-8.1116E^7Epe_{ps}-31183.8072T^2-3.8558E^6T.Epe_{ps}+7.8905E^7Epe_{ps}^2$;

$Emission_{NOx}=-2.7833E7-7.168E5T+1.3314E^8Epe_{ps}-53637.4783T^2+1.3968E^6T.Epe_{ps}-1.0535E^8 Epe_{ps}^2$;

3) Environmental investment by the public sector Ein_{ps} (% of GDP):

$Emission_{SOx}=2.2698E^{8}+4.5522E^{6}T-3.3181E^{9}Ein_{ps}-19974.2561T^{2}-3.5177E^{7}T.Ein_{ps}+1.2741E^{10}\ Ein_{ps}^{2}$

$Emission_{NOx}=-2.5759E^{8}-3.2907E^{6}*x+4.0546E^{9}Ein_{ps}\ 63447.6991T^{2}+2.6317E^{7}Ein_{ps}-1.5127E^{10}\ Ein_{ps}^{2}$;

4) Environmental protection expenditure by industry Epe_{ind} (% of GDP):

$Emission_{SOx}=-1.6459E^{7}+9.1537E^{5}T+1.0333E^{8}Epe_{ind}-61724.4775T^{2}-1.4839E6T.Epe_{ind}-9.6138E7Epeind2$;

EmissionNOx=2.3922E7+1.1761E6T-4.349E7Epeind-51008.1155T2-2.3755E6*T.Epeind +4.8595E7 Epeind2;5) Environmental investment by industry Einin (% of GDP):

$Emission_{SOx}=1.2181E^{7}+76593.254^{7}T-3.3871E^{7}Ein_{in}-46834.2554T^{2}-2.9867E^{5}T.Ein_{in}+2.0442E^{8}Ein_{in}^{2}$;

$Emission_{NOx}=1.0764E^{7}+7.9315E^{5}T+4.2981E^{7}\ Ein_{in}-57047.7227T^{2}-4.8827E6T.\ Ein_{in}-1.2763E^{8}\ Ein_{in}^{2}$.

5) Current environmental protection expenditure by industry $CEpe_{ind}$ (% of GDP):

$Emission_{SOx}=1.1293E^{8}-2.4662E^{6}T-5.4759E^{8}CEpe_{ind}-7948.1555T^{2}+6.2332E^{6}T.CEpe_{ind}+7.3626E^{8}\ CEpe_{ind}^{2}$;

$Emission_{NOx}=1.1133E^{7}+1.9393E^{6}T+1.2306E^{8}CEpe_{ind}-71898.2617T^{2}-.4389E^{6}T.CEpe_{ind}-1.4915E^{8}\ CEpe_{ind}^{2}$.

Conclusions. Summarizing the above presentation the following conclusions have been made.

The series of five indicators of the expenditures for environmental protection were set - Resource productivity, Environmental protection expenditure by the public sector and by industry, Environmental investment by the public sector and by industry, Current environmental expenditure by the public sector and Current environmental protection expenditure by industry. They are used to track the trends in their amendment.

For the observation period were processed the data for emissions of sulfur and nitrogen oxides. The numerical models that reflect the impact of the expenditures for environmental protection were obtained. They can be applied to optimize the management of the Environment and to justify the expenditures in national budgets.

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