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Environmental Protection Expenditures and Effects of Environmental Governance of Sustainable Development in Manufacture Enterprise

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Abstract: The article concentrates on the effects of the environmental governance of sustainable development. It examines the relationship between environmental protection expenditures and the effects of the environmental governance of sustainable development. In order to reduce the variables determining the number of effects the Principal Component Analysis was used. Analyses are related to the European Union countries and cover the 2008-2014 period. The research is based on the industry sector. Over the whole analysed period the positive trends in the effects of the environmental governance of sustainable development were observed in the majority of the analysed countries. The results of the analysis show that an increase in environmental protection expenditure is not always followed by an increase in ecological effects.

Keywords: environmental protection expenditure, environmental governance, sustainable development, industry sector

1 Introduction

The concept of sustainable development is a solution to the deteriorating state of the environment, which is the result of human activity. The degradation of the environment, which is connected with a negative environmental impact, will be experienced in full by the future generations. The environmental degradation is often accompanied by economic growth [1, 2], which is connected with the growth of economic activities. They lead to increased emissions of carbon dioxide [3] and other pollutants. It is worth noting that the demand for the quality of the environment is continually growing [4], and societies willingly cover expenditures on environmental protection with the belief that the benefits of such activities outweight the outlays [5].

A pro-environmental activity of enterprises involves considerable costs. Economic goals often stand in opposition to environmental goals. The growing environmental awareness of societies is a major factor behind decisions of businesses to acquire and use money on environmental protection. Therefore, it seems reasonable to evaluate the effects of pro-environmental activities and the efficiency of investments into them.

Outlays connected with environmental protection are the area of accounting which should go along the regulation 538/2014 on the European environmental economic accounts [6]. In order to reduce the emission of pollution and fees connected with it, businesses aim at reducing energy consumption and finance pollution reduction, invest into new methods, technologies, processes and appliances preventing or reducing emissions [7]. Environmental capital expenditures should not only be the result of pro-environmental duties stemming from legal regulations. They should also be an element of market competitiveness and other benefits of investments into technologies reducing pollution [8, 9, 10]. Such approach to the role of environmental protection expenditures follows from different types of reasons for pro-environmental activities: legal (responsibilities established by environmental law), economic (savings, finding new clients, improvement of the image, brand consolidation) and mental (transplanting personal respect for the environment into the enterprise) [11, 12]. Well prepared environmental protection regulations lead to better efficiency of resources as well as to increased innovativeness and competitiveness of companies [13].

Various processes used in industrial plants are among the main sources of air pollution [14]. Industry is especially harmful to the environment due to its high level of air pollutants emission. Therefore, plants take up activities which can reduce the negative effects of their operation on the environment. Accordingly, the goal of the article is to determine the influence of environmental protection expenditures on the effects of sustainable development of industry in the EU countries.

2 Measures of the environmental governance of sustainable development in plants in the EU

Integrated governance is the basis for the grouping of indexes of sustainable development of a country. It presupposes the coexistence of four orders: social, economic, environmental and institutional-political. The article concentrates on environmental governance because of the impact of plants on the environment. Environmental governance encompasses areas connected with the use of natural resources and activities reducing the negative impact of enterprises on the environment. The measures evaluating environmental governance in plants allow for an evaluation in terms of: climate change, electric energy sources and consumption, air pollution reduction, use of water resources, waste management.

The author assumed the following measures of the effects in terms of environmental governance:

- Greenhouse gases emissions (in million tonnes of CO2 equivalent),
- Sulphur oxides emission (in tonne),
- Nitrogen oxides emission (in tonne),
- Ammonia emission (in tonne),
- Carbon monoxide emission (in tonne),
- Non-methane volatile organic compounds emission (in tonne),
- Methane emission (in tonne),
- Nitrous oxide emission (in tonne),
- Carbon dioxide emission (in tonne),
- Particulates < 2.5µm emission (in tonne),
- Particulates < 10µm emission (in tonne),
- Electricity consumption (in GWh),
- Generation of waste (in tonnes).

The evaluation concentrates on the EU countries. A selection of measurements for the analysis was dictated by the availability of relevant data.

The level of greenhouse gases emission can be treated as the measure determining climate change. Although there is an ongoing debate on the influence of greenhouse gases on climate change [15], the emission of these gases, and especially of carbon dioxide, has become a major ecological and political problem of the whole world [16]. The increase in the greenhouse gases emission is mainly related to the combustion of fossil fuels [17]. Fig. 1 shows greenhouse gases emission from fuel combustion in manufacturing industries and construction in European Union countries.

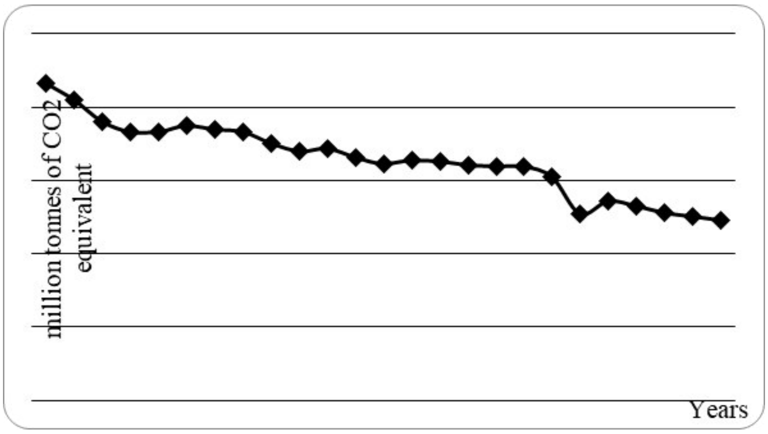

Figure 1
Greenhouse gases emission from fuel combustion in manufacturing industries and construction in European Union countries (28 countries)

Source: Own elaboration based on Eurostat database

The level of greenhouse gases emission caused by fuel combustion in manufacturing industries and construction has been decreasing since 1990. Over the 1990-2014 period the emission was decreasing on an annual average by 2,32%, and in 2014 it was 43% lower than in 1990. Carbon dioxide, which is an air pollutant, has the greatest share in greenhouse gases. Annual average changes in air pollutants emission in the 2008-2014 period are shown in table 1.

Air pollution	Average change rate [in %]
Sulphur oxides	-7,99456
Nitrogen oxides	-4,92011
Ammonia	-1,92433
Carbon monoxide	-3,515
Non-methane volatile organic compounds	-3,12275
Methane	-0,38587
Nitrous oxide	-18,2162
Carbon dioxide	-3,40835
Particulates < 2.5µm	-3,90648
Particulates < 10µm	-3,82232

Table 1
Average change rate for air pollution emissions from manufacturing in European Union countries (28 countries).

Source: Own elaboration based on Eurostat database

An annual average decrease of all air pollutants can be observed: the biggest drop is visible for nitrous oxide, and the smallest for methane.

Another important area of sustainable development of enterprises is energy consumption. An analysis of the rate of change in the 2004-2015 period reveals an annual average decrease in energy consumption by 1,05%. The decrease, however, is largely a result of reduced production caused by the economic crisis which took place during this period. An annual average decrease in energy consumption in the 2004-2015 period characterized the majority of the EU countries. An annual average increase in energy consumption was only observed in Hungary, Ireland, Lithuania, Poland, Austria, and the Czech Republic, but it was slight - ranging from 0,33% (the Czech Republic) to 4,49% (Hungary).

There was also an annual average decrease in the quantities of waste generated by industry in the 2008-2014 period, for both the whole European Union and the majority of member states. The steepest reduction of average annual waste quantity was recorded in Croatia (decrease by 18,37%), Cyprus (15,95%) and Portugal (12,66%). Countries like: Malta, Germany, Greece and France saw an annual average increase in the quantity of waste respectively by 9,16%, 7,31%, 0,72% and 0,17%.

3 Research methodology

The analysis concentrated on values which were the basis for the evaluation of effects in terms of environmental governance of sustainable development in plants. The goal of the study was to determine the influence of environmental protection expenditures on the environmental effects of the industry sectors of EU countries. The discussed population consists of 23 countries of the European Union (with the exclusion of Denmark, Latvia, Luxembourg, Malta, the United Kingdom). The analysis covers the years 2008, 2010, 2012 and 2014. A selection of countries and measurements for the analysis was dictated by the availability and completeness of relevant data. The data come from the data base of the Statistical Office of the European Communities Eurostat [18].

The influence of environmental protection expenditures on environmental effects was determined with the use of simple relationship analysis methods. The force and direction of the influence was examined on the basis of the Pearson correlation coefficient. The analysis was carried out with the use of the Statistica 12.0 package.

Table 2 shows the data for the analysis, which determine the effects of the environmental governance of sustainable development.

Area of environmental governance of sustainable development	**Variable**
Climate changes	Greenhouse gases emission [million tonnes of CO2 equivalent]
Air pollution	Sulphur oxides emission [tonne] Nitrogen oxides emission [tonne] Ammonia emission [tonne] Carbon monoxide emission [tonne] Non-methane volatile organic compounds emission [tonne] Methane emission [tonne] Nitrous oxide emission [tonne] Carbon dioxide emission [tonne] Particulates < 2.5µm emission [tonne] Particulates < 10µm emission [tonne]
Energy use	Electricity consumption [GWh]
Waste management	Waste generated [tonnes]

Table 2
Statistical variables for the analysis

Source: Own elaboration

The author also assumed two variables determining environmental protection expenditure: Investment in equipment and plant for pollution control (in million Euro) and Investment in equipment and plant linked to cleaner technology, the so-called integrated technology (in million Euro).

In order to minimize the number and dimensionality of variables determining the effects of the environmental governance of sustainable development, the Principal Component Analysis (PCA) was applied. PCA was also required for the reason of a high level of correlation of some variables.

4 Results

The conclusion uniform for all discussed years is that there is one unobservable variable which is a combination of initial variables (the so called principal component). One principal component was distinguished on the basis of a scree test, irrespective of the scree's starting point. Table 3 presents the values of the analyzed variables as well as a part of the variance distinguished by the first principal component.

Year	Eigenvalue of the first principal component	% of the variance distinguished by the first principal component
2008	9,622474	74,01903
2010	9,403568	72,3351
2012	9,426871	72,51439
2014	9,532389	73,32607

Table 3
Eigenvalues for the analyzed variables

Source: Own elaboration

The component corresponding to the first and highest eigenvalue accounts for more than 72% of the total variance in each of analyzed years.

Eigenvectors were calculated for the obtained eigenvalues (table 4).

Variable	Eigenvector for the first factor			
	2008	**2010**	**2012**	**2014**
Greenhouse gas emission	-0,311315	-0,310409	-0,311670	-0,309716
Sulphur oxides	-0,293780	-0,277239	-0,284483	-0,290745
Nitrogen oxides	-0,307977	-0,315824	-0,313985	-0,311427
Ammonia	-0,187717	-0,171120	-0,190885	-0,193972
Carbon monoxide	-0,279805	-0,276576	-0,297213	-0,288754
Non-methane volatile organic compounds	-0,304108	-0,302032	-0,306929	-0,306700
Methane	-0,200560	-0,203415	-0,187076	-0,174067
Nitrous oxide	-0,265876	-0,255554	-0,243519	-0,266367
Carbon dioxide	-0,314914	-0,317353	-0,318132	-0,317191
Particulates < 2.5µm	-0,266405	-0,265220	-0,250851	-0,245169
Particulates < 10µm	-0,275854	-0,277004	-0,264933	-0,258348
Electricity consumption	-0,301053	-0,300941	-0,300765	-0,300500
Generation of waste	-0,261019	-0,291553	-0,292035	-0,297447

Table 4
Eigenvectors for the analyzed variables

Source: Own elaboration

Negative values of eigenvectors mean that the increase in the value of individual variables (effects) influences negatively the value of the first component. Therefore, the higher the energy consumption, waste quantity and the values of the emissions of individual pollutants, the lower the value of the first component.

For the singled out variables the correlation coefficient which determines the force and direction of the relationship between environmental protection expenditures and the effects of the environmental governance of sustainable development which were described by one unobservable variable specified on the basis of PCA were estimated. The results are shown in table 5.

	Pearson linear correlation coefficient between	
Year	**Investment in equipment and plant for pollution control and effects of environmental governance of sustainable development**	**Investment in equipment and plant linked to cleaner technology and effects of environmental governance of sustainable development**
2008	-0,94603	-0,77398
2010	-0,94148	-0,81252
2012	-0,85012	-0,90534
2014	-0,8402	-0,89382

Table 5
Pearson linear correlation coefficient between environmental expenditures and effects of environmental order of sustainable development (described by one unobservable variable specified on the basis of PCA)

Source: Own elaboration

All analyzed years show a high negative relationship between environmental protection expenditures and effects of environmental order of sustainable development expressed by the first component. This lets us conclude that investment in equipment and plant for pollution control and investment in equipment and plant linked to cleaner technology in the sector of industry in individual EU countries grow according to the values of individual effects. This relationship is to be expected as the volume of output should translate into the scale of the phenomenon. In order to find out if changes in outlays are followed by positive changes in the volume of effects, the correlation indexes between the determined dynamics indexes for individual variables were calculated. The results are presented in table 6.

Dynamics indexes	Pearson linear correlation coefficient between	
	Changes in investment in equipment and plant for pollution control and changes in effects of environmental governance of sustainable development	**Changes in investment in equipment and plant linked to cleaner technology and changes in effects of environmental governance of sustainable development**
Average change rate	-0,14656	-0,21675
Dynamics index 2010/2008	0,029072	-0,3076
Dynamics index 2012/2010	0,587832	0,265472
Dynamics index 2014/2012	-0,22721	0,192591
Dynamics index 2014/2010	-0,15319	-0,02864

Table 6
Pearson linear correlation coefficient between changes in environmental expenditures and changes in effects of environmental order of sustainable development (described by one unobservable variable specified on the basis of PCA)

Source: Own elaboration

Analyzing the Pearson correlation coefficient between the dynamics of change in environmental protection expenditures and effects of environmental governance of sustainable development expressed by the first component, it is clear that the only statistically significant correlation occurs between changes in the value of investment in equipment and plant for pollution control and changes of the first component expressed by the dynamics index for the 2012 in relation to the year 2010. A positive correlation indicates that an increase in the dynamics index of investment in equipment and plant for pollution control causes a reduction of dynamics index for individual variables comprising the first component. This means that changes in environmental protection expenditures in the sector of industry of individual countries translate into positive changes in terms of the emission of air pollutants, energy consumption and the volume of generated waste. The lack of statistical relationships between variables changes expressed by the measures of dynamics means that expenditures have not brought bigger benefits, but have not caused negative changes in the analyzed effects either. In other words they prevented the value of the effects from deterioration in the consecutive years in comparison to the base year.

Conclusions

The concept of sustainable development is the answer to the deteriorating state of the environment caused by human activity. Environmental impact degrades the environment which will likely become a burden for future generations. The concept of sustainable development aims at capturing the full picture of the civilizational development of societies. The premise of the concept is to use resources more effectively along the economic growth. Hence the need for an evaluation of the efficiency of activities which on one hand foster a constant development which caters to the needs of contemporary societies, and retain this opportunity for future generations on the other. Sustainable development is based on a combination of three groups of factors: economic, environmental and social. The article touches upon the environmental factors only.

In an effort to improve their competitiveness, gain more clients, grow sales and profits, enterprises make numerous pro-environmental investments. This way they reduce the negative impact on the environment and build a positive brand image. Over the 2008-2014 period positive trends in the effects of the environmental governance of sustainable development for the majority of the analysed countries were observed. Obtaining positive environmental effects requires financial outlays though. The analysis was carried out for expenditures expressed by investment in equipment and plant for pollution control and investment in equipment and plant linked to cleaner technology. Unfortunately the results of the analysis show that an increase in expenditure is not always followed by an increase in effects. It can be caused by factors such as a reduction of production volume in plants, socio-economic or political crises in individual countries or limiting the outlays on investment in equipment and plant for pollution control and linked to cleaner technology. The study concentrated only of environmental effects with the exclusion of economic and social effects. Accordingly, the research should be followed up by a detailed analysis of the relationships individually for distinguished areas of environmental governance. The study might also be complemented by an analysis of economic and social effects.

Sustainable development has become one of the approaches to preventing excessive impact on all elements of the environment through a reasonable use of resources and environmental values with a subsequent determination of requirements helping maintain biological and landscape variety [19]. Even despite it is may be costly, undertaking pro-environmental activities should be an essential element of the functioning of businesses. It is important to remember that the effects of pro-environmental activities are often immeasurable, which makes it hard to connect the costs of their implementation with measurable economic benefit.

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