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Environmental and Business Measurement for Sustainable Development: Emissions and Enterprises' Sales Linkages among Slovak Industrial Enterprises

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Abstract: Like in many post-communist countries, the economic activity of Slovak industrial enterprises causes harmful environmental effects. One of the ecological commitments for Slovakia under the EU Effort Sharing Regulations is to avoid increasing emissions. This engagement requires new, innovative technological processes and the consideration of sustainable principles. No more is enough to look "green" on the outside, but above all important to act. The main idea of our article is to offer an appropriate indicator for enterprise's management that enables them to implement relevant environmental measures. The article reveals the nexuses between the values of sulphur dioxide emissions of 75 industrial enterprises in different regions of Slovakia and their obtained revenues during 2014-2019. The conducted study and its results will be valuable managers guidance on recording and assessing the degree of sustainable development. Furthermore, based on the economic-environmental ratio indicator created by us, we can derive a myriad of similar indicators characteristic of individual industrial enterprises. Therefore, it enables management to make relevant decisions and act sustainably, as post-communist countries as members of the EU declared in their environmental policies.

Keywords: sustainability; sustainable development; sustainable manufacturing; emissions

JEL Classification: Q01; M00; L00

1. Introduction

The unlimited human needs are a severe problem according to the limited resources. This fact represents a particular economic paradigm and is, at the same time, a driving force in progress towards the efficient use of factors of production. Despite the development of science and technology, which generate new innovative processes, various negative externalities arise. The consequences of these activities are accompanied on the one hand by economic production and the satisfaction of predominantly material needs, on the other hand by massive pollution (air, water, soil, etc.) with unavoidable consequences that threaten meeting the needs of future generations. It is evident that the cultural distinction significantly affects the enterprise's management and is closely related to the history and customs in the region. The rapid expansion of industrial production in the second half and at the end of the 20th century significantly affected the Slovak and other post-communist countries' national and business results. Subsequently, the environmental damage forced these countries as new EU' members

to deal with it and, through environmental policy, create a direction toward sustainable production. For 2030, according to the current legislation, EU Effort Sharing Decision Slovakia's national target will be to reduce emissions by 12% compared to 2005 levels determined by Regulation (EU) 2018/842.

The article has three main parts. First, the literature review explains Slovakia´s road to sustainability and the related direction of its environmental policy. Then we are following with the methodological and analytical part. Then, with the implementation of the usage of statistical analyses, we describe our findings of the relationship between produced emissions of sulphur dioxide and revenues from related industrial enterprises in Slovakia. Finally, our results are completed by creating our new suggested economic-environmental ratio indicator.

1.1. Literature Review – Sustainable Development and Its Historical Background

The initial impetus that led to sustainable development activities was the publication of Silent Spring by American biologist Rachel Carson (Moldan, 2003). This publication has been critical of the threat of toxic chemicals, which negatively impact human health and constitute a significant threat to the environment. Subsequently, the United Nations (UN), as the leading player in the effort to avert the ecological crisis, began to address the issue of the environment. In 1972, ten years after the book Silent Spring, the first official conference, called the Stockholm Coup, launched a global effort to combat environmental pollution. The United Nations Environment Program (UNEP) was established as part of the Stockholm Conference and followed by initiatives of UNEP, the International Union for Conservation of Nature (IUCN) and the World Wide Fund for Nature (WWF), the World Conservation Strategy (WCS) in 1980. This strategy refers to "development that can be considered sustainable", especially when we consider improving people's quality of life and protecting the world's environment". UNEP (1980) recognizes that in this context, it is necessary to maintain "the management of the use of the biosphere by man so that it can provide its potential for the satisfaction of future generations." (UNEP, 1980). A few years later, in 1987, the UN Commission established the World Commission on Environment and Development (WCED). This WCED in the Brundtland Report ("Our Common Future") characterized the term "sustainable development", which thus gained general acceptance among states. The definition of sustainable development was as follows: "as development that meets people's needs without restricting future generations in meeting their needs." (WCED, 1987) Reconciling economic development while maintaining social and environmental balance has become a general priority. In 1992, at the United Nations Conference on Environment and Development - UNCED in Rio de Janeiro, 4 key documents were adopted, which were the starting point for developing sustainable development strategies. These documents included the Rio Declaration (containing 27 principles), the Convention on Biological Diversity, the Framework Convention on Climate Change and AGENDA 21.

The need to address these current global challenges associated with economic activity poses a significant threat to the economy's future and threatens life on Earth, with more and more countries in the world realizing it (Pham et al., 2021; Wilhite et al., 2014). Therefore, the UN issued recommendations to all Member States to develop national strategies based on these

documents. For this reason, the UN General Assembly created the Commission for Sustainable Development - CSD, which included 53 member states of the world. The commission's main task was to support the implementation of UNCED documents and its subsequent monitoring at the regional, national and global levels. In 2002, the World Summit on Sustainable Development in Johannesburg evaluated the ten-year development of the implementation of AGENDA 21. (Ministry of the Environment of the Slovak Republic, 2001). To this day, the UN has been predetermining initiatives and standards into EU policy and being part of national legislation, being the primary concern of consumers, and reflected in various voluntary activities (Krause, 2019).

The priority of incentives and standards is to focus on the rational and efficient use of resources, the protection of climate change and the safeguarding of the diversity of nature. These activities significantly impact the current state of the environment, man's existence, and biodiversity. The professional public and organizations respond to this by creating a set of standards, tools, measures, or strategies to eliminate the problems that have arisen and prevent further growth into the future. Achieving sustainable development is a crucial priority in addressing social and environmental issues. (Linnenluecke et al., 2017). Today, sustainable development is an important area of development for world society. Integration groups are also aware of this fact, which introduce elements of sustainable development into practical life. One of the significant integration groups that deal with sustainable development is the European Union. It represents an increased initiative in addressing sustainability issues, particularly since the Council of Europe Summit in Cardiff in 1998. The main reason for the summit was climate change, the expansion of limited resources, dynamic population growth, environmental pollution, and others. The dominant areas for addressing these issues include industry, transport, energy and agriculture. In 2015, UN member states approved the AGENDA 2030 program for sustainable development at the United Nations Sustainable Development Summit.

1.2. Forming Environmental Policy

The general goal of every enterprise on the market existence, also in post-communist countries, has always been and still is - to maximize its profits. Every enterprise wants to be better than its competitor, get long-term development and business growth (Malichova & Durisova, 2015; Potkany et al., 2009), and it is a natural force in the market and an effort to control it. So, in recent years external, and internal influences have forced the enterprise's management to pay attention to the environmental impacts of economic activity. As a result, there is pressure on enterprises that must implement sustainable principles in the production process. However, the involvement and implementation of sustainability elements vary between countries on Earth. It is evident that transforming post-communist countries need to make good use of their market potential following the principles of sustainable development (Scrieciu & Stringer, 2008). However, realizing the appropriate use of the possibility of the enterprise in the former post-communist country was not easy. Once centrally planned economic systems fell under the responsibility and ownership of the government, with regulated trade flows and factor prices being strictly controlled and monitored (Demekas &

Khan, 1991). However, state control over the market varied in communist countries. In Czechoslovakia, Poland and Hungary, progressive, alternative, and organized structures to communism emerged (Sowards, 1996). During this period, there was a high decline in the quality of the environment. The reason was the rapid growth of industrial enterprises. The number of industrial enterprises has increased in engineering, metalworking, and the chemical industry. However, a stronger emphasis on industrial development in post-communist states has also brought shadowy effects in environmental pollution, which has not received much attention (Haggard & Kaufman, 2008). The reason was the adoption of the Marxist ideology on natural resources, which stated that the environment has no intrinsic value but should primarily serve humanity and human needs (Mazurski, 1991). Despite this fact, the industry's boom took on incredible proportions. Today, it is challenging and strenuous for post-communist countries to get out of the shadow of the communist past. In most countries, democratic regimes consolidated. Several years of efforts by these countries to transform and get economic, social, and cultural power are in process (Butek & Klieštik, 2017).

The changes made in post-communist countries focused primarily on the elementary parts and reorganization (Vilinovič, 2011). We encounter the challenges of transforming global requirements into local measures related to the change processes in enterprises (Sákal & Fidlerová, 2012). In this case, we are talking about industry and production, which significantly impact the biosphere due to the emissions produced. Examining the impacts of an enterprise's activity is, therefore, one of the fundamental pillars for achieving sustainable development in interactions with the environment, as confirmed by international studies by the authors (Epstein & Roy, 2001; Schaltegger & Burrit, 2010; Johnson & Schaltegger, 2015; Govindan et al., 2016). According to Mirchi et al. (2012) and Turner et al. (2016), creating a holistic framework for better grasping and managing uncertainty is necessary, especially in the enterprise's environment. The creation of such a complex apparatus brings with it many complications. From a methodological point of view, the economic, social, and environmental aspects need to be considered when developing and implementing sustainable policies (Tsai et al., 2020). The production process and managerial decision process about investments are influenced by appropriate economic policy, in the case of environmental innovation by environmental policy. (Malichova et al., 2016, Durisova et al., 2020)

1.3. Environmental Policy of the Slovak Republic from 1993

As social and environmental balance became a priority in 1992 and the Slovak Republic was established in 1993, the new government approved the Strategy – principles and priorities of the State Environmental Policy, which has not been updated since 2020. Upon acceding to the EU in 2004, Slovakia made a considerable investment in aligning its environmental regulatory framework with its new obligations as an EU member. There has been a significant evolution in the mix of environmental policy instruments, including regulatory, economic and information-based measures (OECD, 2011). Even though efforts based on international benchmarking indicators lag the comparable industrialized countries in air quality and waste management, a document entitled Strategy of Environmental Policy of the Slovak Republic until 2030 (referred to as Envirostrategy 2030) was prepared. The predecessors of this document

were several vital strategies based on UN AGENDA 2030, such as the National Strategy for Sustainable Development of the Slovak Republic, National Reform Program 2016, Stability program of the Slovak Republic for the years 2016-2019 and the like. In total, more than 42 concepts, national and operational programs have been created with a focus on national SDG priorities, which include SDGs 3, 6, 7, 8, 9, 10, 11, 12, 13 and 15 with an environmental dimension. The main goal of Envirostrategy 2030 is to determine the strategic direction of what public decisions are expected to be made, which would significantly contribute to the sustainable approach of the country.

2. Methodology

Enterprises in post-communist countries are gradually moving towards changes towards sustainable production. Relation between the economic and environmental impacts that result from the production of enterprises are essential. Therefore, a description of the continuity of environmental-economic quantities and examine which quantities are suitable for this analysis. Following the studies about the damaging effects of air pollution and its impacts on human health, ecosystems, and biodiversity (Schraufnagel et al., 2019; WB, 2019; WB & IEP, 2021), we focused our research on the impact of the emission of sulphur dioxide (SO2), because it is a significant contributor to air pollution. The negative externality of SO2, health impact derives mainly from direct exposure to SO2. The most significant source of SO2 in the atmosphere as burning fossil fuels in power plants and other industrial facilities. Other sources of SO2 emissions include industrial processes such as extracting metal from natural sources such as volcanoes, locomotives, ships and other vehicles and heavy equipment that burn fuel with high sulphur content. In Slovakia, the SO2 emissions were shown in 2000-2010 a downward trend, mainly due to a change in fuel use.

In the practical part of this article, we analysed the relationship between the produced emissions of Sulphur dioxide (SO2) and revenues from the sale of goods and services of related industrial enterprises in Slovakia. Not all industrial enterprises in Slovakia are obliged to record and report produced emissions. However, sulphur dioxide emissions are among the five primary pollutants from enterprises that the Slovak Hydrometeorological Institute recorded. Currently, 77 enterprises in Slovakia are obliged to record the produced emissions of sulphur dioxide. In this analysis, we deal with data from 75 enterprises due to the incomplete data from two enterprises. Therefore, the number of industrial enterprises in this study is 75, and the appropriate data were collected from 2014-2019.

We used a parametric statistical method of analysis of variance, ANOVA. In the ANOVA, we focused on regression, which examines the relationship of dependence between two or more variables.

3. Results

Our research started with setting the following hypotheses, which were statistically verified, and we provide the results in this section.

- *H1: The values of sulphur dioxide emissions in selected industrial enterprises are constant in recorded years so there is a reported change in the revenues of selected industrial enterprises.*
- *H2: Sulphur dioxide emission values do not change in the regions of Slovakia.*
- *H3: Acquired revenues values of selected industrial enterprises in Slovakia statistically report a nexus on the production of sulphur dioxide emissions.*
- *Hypothesis H4: The statistical model is not statistically significant.*

The paper deals with data on SO2 emissions produced in individual years and regions. Table 1 shows the population and area of each region of the Slovak Republic.

The established hypotheses were verified based on one-way analysis of variance (ANOVA). The significance level was set at 0.05 in both cases.

Based on the significance, which has a value greater than the specified level of significance, we accept hypothesis H1, which means that sulphur dioxide emissions are constant in each recorded year (Table 2). This fact is quite serious.

In the case of H2 hypothesis verification, the significance value was lower than the significance level (Table 3), which means we reject the hypothesis, and its alternative form applies. The conclusion is that the values of sulphur dioxide emissions are different in the regions of Slovakia.

Table 1. Characteristics of the regions of the Slovak Republic (Statistical Office of the European Communities, 2019)

Region	Population	Area (km²)
Banskobystrický	647,874	9,454
Bratislavský	659,598	2,053
Košický	800,414	6,753
Nitriansky	676,672	870.7
Prešovský	825,022	8,993
Trenčiansky	585,882	4,502
Trnavský	563,591	4,145
Žilinský	697,502	6,808.8

Table 2. ANOVA Data analysis of sulphur dioxide during recorded years

SUMMARY				
Groups	Count	Sum	Average	Variance
2019	8	3,811,990.7	476,498.8	3.33518E+11
2018	8	3,401,028.3	425,128.5	2.66188E+11
2017	8	2,999,612.1	374,951.5	2.01193E+11
2016	8	2,749,018.9	343,627.4	2.40369E+11
2015	8	1,287,811.1	160,976.4	12787772523
2014	8	1,194,479.4	149,309.9	18508069974

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.48217E+11	5	1.49643E+11	0.84	0.53	2.44
Within Groups	7.50794E+12	42	1.78761E+11			
Total	8.25616E+12	47				

Table 3. ANOVA Data analysis of sulphur dioxide in the regions of the Slovak Republic during the recorded years

SUMMARY				
Regions	Count	Sum	Average	Variance
Banskobystrický	6	123,962.4	206,615.4	1,965,019,749
Bratislavský	6	6,874,653.2	1,145,775.5	4.84241E+11
Košický	6	2,594,276.8	432,379.5	6,909,661,990
Nitriansky	6	609,007.0	101,501.2	309,677,246.4
Prešovský	6	1,427,493.6	237,915.6	33,539,799,239
Trenčiansky	6	395,158.2	65,859.7	601,645,070.1
Trnavský	6	239,167.2	39,861.2	231,928,113.7
Žilinský	6	2,064,492.0	344,082.0	36,843,999,326

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.43294E+12	7	7.76135E+11	11	1.18442E-07	2.25
Within Groups	2.82322E+12	40	70580387247			
Total	8.25616E+12	47				

This alternative hypothesis points out that the production of sulphur dioxide emissions varies between regions, so in Slovakia, we have different environmental qualities in different regions in terms of sulphur dioxide emission. In regions with high production values of these emissions, there can be a significant negative impact on human health. High levels of oxide emissions in the air cause people diseases, especially the respiratory tract, cardiovascular diseases, headaches, and depression (Mináriková, 2001).

In the next part of the analysis, we determined the dependence of selected variables using regression and correlation analysis. First, a regression model is determined, the statistical significance of which will be determined at the level of 0.05 using an F-test.

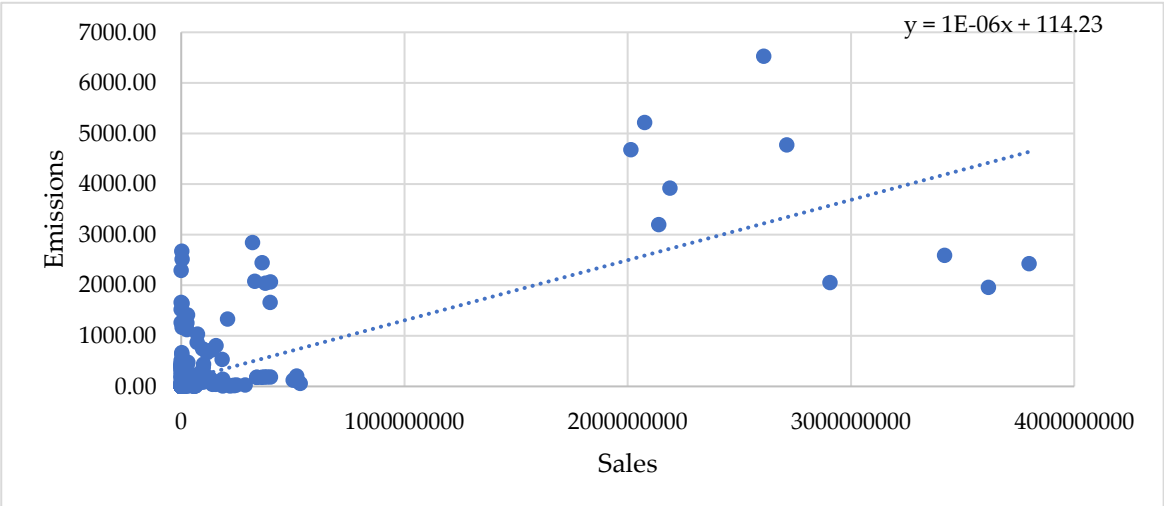

Figure 1. Dependence of sales and emissions of sulphur dioxide

The graph of the dependence of sales and emissions of sulphur dioxide shows a direct linear dependence. In Figure 1, we can notice that two primary areas are being created. The

first area, the cluster is enterprises in the regions, which together generate low sales of up to 1,000,000,000 euros and produce low emissions of sulphur dioxide up to 3,000 tons. The second cluster is enterprises, which together generate high sales of 200 billion euros. A gap is emerging between these two significant clusters, which arises because in Slovakia, we have a minimum number of large industrial enterprises and many small industrial enterprises that report produced sulphur dioxide emissions.

Table 4. Output of the regression between the produced emissions and revenues of enterprises

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.72				
R Square	0.52				
Adjusted R Square	0.52				
Standard Error	290,276,297.7				
Observations	449				
ANOVA					
	df	*SS*	*MS*	*F*	*Sig. F*
Regression	1	4.156E+19	4.156E+19	493.23	3.48E-74
Residual	447	3.76644E+19	8.42603E+16		
Total	448	7.92244E+19			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	-6510803.4	14,401,032	-0.45	0.65	
Emission	440,457.9	19,832.5	22.2	3.478E-74	

The resulting dependence has a value of 72.43%, which means a strong dependence between variables. The correlation coefficient acquires a value of 52.46%, which means high tightness, resp. high probability that phenomenon B is caused by phenomenon A. Based on this analysis, we can state the truth of the established hypothesis H3, confirming the hypothesis. The acquired values of revenues of industrial enterprises in Slovakia are highly dependent on sulphur dioxide emissions.

The regression function has the form: (f): y = 440,457.88x -6,510,803.38.

3.1. Creation of the Indicator ERIsox, - a Tool for Better Managerial Decision Making

A high dependence was found in analysing the relationship between the values of produced sulphur dioxide and obtained sales of industrial enterprises. For this reason, we move on to the second part of the article, which is the creation of the ERIsox (Environmental Ratio Indicator of sulfur dioxide), which has the form:

$$ERI_{SOX} = \frac{turnover\ of\ the\ enterprise\ during\ the\ period\ (per\ year)}{missions\ of\ sulfur\ oxides\ (in\ tonnes\ per\ year)} * 1\ 000\ 000 \qquad (1)$$

and presupposes practical use by managers in enterprise.

We used this ratio indicator to analyse the production of sulphur dioxides and the obtained revenues of enterprises in the Slovak Republic. The following Table 5 shows the values of the ERIsox ratio indicator in the period 2014-2019 in individual regions of the country.

Table 5. The values of the ERIsox in the period 2014-2019

Region	2014	2015	2016	2017	2018	2019
Banskobystrický	1.85	2.41	1.37	1.87	2.42	2.47
Bratislavský	2.34	2.98	14.95	14.06	16.20	18.22
Košický	4.32	3.37	4.15	3.78	4.51	5.80
Nitriansky	1.34	0.91	0.89	0.89	0.99	1.09
Prešovský	0.62	0.79	0.71	4.10	3.98	4.07
Trenčiansky	0.50	0.86	0.66	0.45	0.45	1.04
Trnavský	0.10	0.45	0.50	0.38	0.46	0.50
Žilinský	0.87	1.11	4.27	4.47	5.00	4.93
Average	1.49	1.61	3.44	3.75	4.25	4.76

The only region that shows significant differences is Bratislava, whose indicator's value has an annual upward trend. The values of the ratio indicator in other regions of Slovakia have a long-term constant character. After excluding the Bratislava region from the sample, the average achieved value of the ratio indicator in Slovakia is 2.04.

Table 6. The average values of the ERIsox in the whole of Slovakia (2014-2019)

Period	2014	2015	2016	2017	2018	2019
AVERAGE ERIsox	1.49	1.61	3.44	3.75	4.25	4.77

The situation that has arisen (Figure 2) shows that the trend showing real data is growing, which is beneficial for the country and beneficial for sustainable direction.

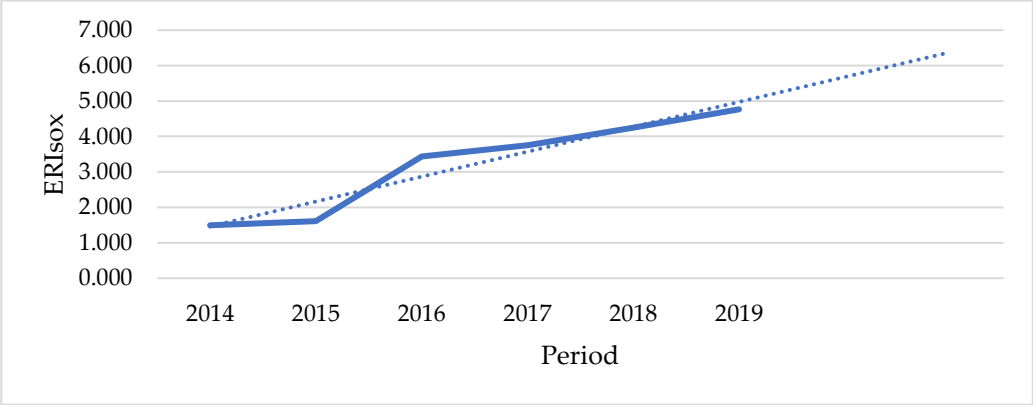

Figure 2. Mean values and forecast of the ERIsox

It is necessary to draw attention to the fact that the positive trend and the forecast of the values of the ratio indicator are significantly influenced by the positive values acquired by the Bratislava Region for a long time.

4. Discussion

From our perspective, economic growth without pollution achieved by clean production requires good management and strategic decisions based on appropriate data. Our intention in this article is to discuss what specific sustainability data or indicators should managers monitor and control due to their particular conditions according to the enterprise's business

and production orientation. Yes, we know that only monitoring sulphur dioxide emissions are not enough, and in some enterprises, even it is not needed or helpful. We chose this substance due to our analysis in the Slovak republic. It indicated that sulphur dioxide emission is one of the main negative externalities produced by industrial enterprises oriented to metal production and metallurgy, chemistry, plastics, energy, and mining. The primary source of sulphur dioxide is burning fossil fuels, such as coal, oil, and natural gas. In recent years, across Europe, much progress has been made to decrease this type of emissions. All this evidence guided us to create the ERIsox indicator. It is effective for mentioned enterprises and could be meaningful information for managers of other industrial enterprises. The primary goal of creating the ERIsox indicator is its ability to record data continuously. Due to the disclosure of Profit and Loss Statements from Slovak enterprises, which have been publicly available for six years, we have narrowed the data recording period for 2014-2019. A broader range of years allows offering more accurate results. Nevertheless, the sample size allowed us better to calculate the correlation and regression between the variables. Therefore, it is not authoritative on how large a sample the survey is conducted if the dependence is sufficiently demonstrable. It is substantial that managers be convinced of the importance of implementing this indicator in the enterprise. The ERIsox indicator can be modified to various financial and environmental indicators if a strong dependence between the given variables is demonstrated. Certainly, indicators should be tailormade according to the given industrial enterprise that burdens the environment. Our viewpoint is to show a possibility, how to parse the relations between environmental and economic indicators. Our findings offer the first contribution for managers to identify appropriate data importance of their monitoring step by step to promote future managerial decisions.

5. Conclusions

Production processes in the industrial sectors of the post-communist countries are changing and, with innovation, becoming more sophisticated. Even though this production focused on producing "use-value" directly rather than generating profit, private ownerships and competitive markets had no chance to produce effectively. This production has many adverse effects, resulting in environmental damages. Air and water pollution abounded. By one estimate, in the late 1980s, particulate air pollution was 13 times higher per unit of GDP in Central and Eastern Europe than in Western Europe. Increasing competitiveness among enterprises but also motivation factors of the employees (Hitka et al., 2019) are a driving force in adopting practices and activities that improve development. They expect that enterprises' production process will have the least possible negative impact on the environment and people healthy quality of life. However, this fact brings with it several underdeveloped factors. These include an insufficiently developed concept of the principles of sustainable development intended for management. Yes, many environmental principles and indicators exist. However, there is a lack of practical instructions on the enterprise's use. Nevertheless, each industrial enterprise is specific, focuses on producing several goods, and requires a unique approach. The ERIsox ratio, which is described in the practical part of this article, is a suitable metric for continuously recording and comparing the development of sustainable

development in the enterprise. Therefore, managers need to respond appropriately to increase the value of the ERIsox indicator. In two cases, it will be caused if the enterprise's revenues increase or emission values decrease. If the values of emissions decrease, and at the same time, the enterprise's revenues increase. In this case, managers will be able to deduce the activity of their enterprise, which produces the given emissions as sustainable. Each post communistic industrial enterprise management can inspire practices in sustainable enterprises. Moreover, they can consider how quickly they want to get out of the shadow of communist production.

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Conflict of interest: none

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