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EXOGENOUS STABILITY AND SUSTAINABLE DEVELOPMENT OF ENERGY ENTERPRISES IN THE V4

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Purpose: The paper's main aim is to assess the impact of macroeconomic, social and environmental stability on the sustainable development of energy enterprises in the Visegrad Group (V4: the Czech Republic, Hungary, Poland and Slovakia) from 2008 to 2020.
Design/methodology/approach: To assess a statistically significant relationship, we use the correlation coefficients, the Ordinary Least Squares and the Seemingly Unrelated Regression method.
Findings: The research results indicate that macroeconomic, social and environmental stability have a statistically significant impact on the sustainable development of the energy sector.
Research limitations/implications: The sample size is small for any generalization.
A mixed method approach in the future could contribute to a holistic finding.
Practical implications: It is recommended to coordinate macroeconomic, social and environmental policies to achieve positive results in the energy sector. Renewable energy and green energy sources can play a pivotal role here.
Originality/value: This paper fills the research gap regarding assessing the impact of macroeconomic, social and environmental stability on the sustainable development of the energy sector in the V4 countries; this is important for the policies of countries experiencing political transformation. Moreover, the energy sector is important for countries' national security in the current geopolitical conditions related to the raw materials crisis and the war in Ukraine.

Keywords: sustainable development, energy sector, the Visegrad Group.

Category of the paper: Research Paper.

1. Introduction

Sustainable energy enterprises (SD) development incorporates economic, social and environmental goals. It is conditioned by many exogenous and endogenous factors and has a decisive influence on the competitiveness and expansion of business entities (Pieloch-Babiarz et al., 2021). The conditions for the SD are complex and a consequence of globalization processes, the development of modern ICT technologies, social changes and evolutions in the approach to the procedure of economic processes (Misztal et al., 2022; Kuzma, Sehnem, 2022).

Enterprises limit the emission of air pollutants, and the amount of waste contributes to maintaining the continuity of processes related to protecting natural resources and the sustainability of economic processes (Simionescu et al., 2021). The implementation of SD by enterprises is associated with the need to adapt to changing environmental conditions, continuous learning and reorienting the business's goals towards increasing value for stakeholders. SD occurs in specific socio-economic conditions, and its level is influenced by both the external environment and the situation inside the company (Zhou et al., 2022; Wang et al., 2022).

The last research results indicate that socio-economic conditions and regulations regarding protecting the natural environment affect enterprises' decisions to implement SD goals (Nazi, 2022; Barska et al., 2022; Kostakis, Tsagarakis, 2022). Some studies indicate that economic and social progress negatively affects the state of environmental protection, while nature protection regulations contribute to the implementation of innovations and eco-friendly solutions (Udemba et at., 2021). Some researchers show that economic growth has been decoupled from environmental protection (Camporek et al., 2022; Misztal et al., 2021).

SD is significant for macro-social stability, and decisions to produce and supply energy must include renewable energy sources (Cergibozan, 2022; Cader et al., 2021; Islam et al., 2022; Simionescu et al., 2021). Some studies indicate that macroeconomic stability positively impacts the sustainable development of energy companies (Misztal et al., 2022; Camporek et al., 2022; Marti, Puertas, 2022).

The paper's main aim is to assess the impact of macroeconomic, social and environmental stability (exogenous stability) on the sustainable development of energy enterprises in the Vise-grad Group (V4: the Czech Republic, Hungary, Poland and Slovakia) from 2008 to 2020. The research covers the period from the financial crisis to the Covid-19 pandemic. We want to check how transformed economies cope with getting out of the eco-nomic crisis.

The Visegrad Group (V4) is an informal regional form of cooperation between four Central European countries - Poland, the Czech Republic, Slovakia and Hungary, which are connected not only by their proximity and similar geopolitical conditions but, above all, by common history, tradition, culture and values. V4 has been operating since 1991. In addition to European issues, cooperation within the V4 focuses primarily on Central Europe, information exchange, and cooperation in culture, science, education and youth exchange. The V4 are the sixth economic power and the third consumer market in Europe. One of the key aspects of policy sustainability and stability is macroeconomic stability.

We use the correlation coefficients (Pearson's r, Spearman's rho, gamma, and Kendall), the Ordinary Least Squares (OLS), and the Seemingly Unrelated Regression (SUR).

A novelty in our paper is the creation of models of the impact of macroeconomic (MSP), social (SSP) and environmental stability (EnvSP) on the SD. A contribution to the literature on the subject is developing an original approach to creating social and environmental stability indicators. For this purpose, we create the SSP and EnvSP pentagon. SSP is based on the following pillars: population, health conditions, education, labour and social protection expenditure. EnvSP is based on greenhouse gases emission, the generation of waste, water made available for use, the production and consumption of chemicals, and biodiversity.

Our models have several limitations associated with the selection of analytical indicators and the creation of the pentagons. Nevertheless, the research results are important for operational and strategic decisions by company managers and for macroeconomic policy and environmental protection. They can also support the authorities of the Visegrad Group in making findings regarding the directions of reforms of energy economy factors.

The study includes an introduction, materials and methods, research methodology, results, discussion, and conclusion. The review of scientific publications was based on the Scopus and Web of Science lists. The data for the analysis come from Eurostat databases. For the calculations, we used Statistica and Gretl software.

Our paper fills the research gap regarding assessing the impact of macroeconomic, social and environmental stability on the sustainable development of the energy sector in the V4 countries; this is important for the policies of countries experiencing political transformation. Moreover, the energy sector is important for countries' national security in the current geopolitical conditions related to the raw materials crisis and the war in Ukraine.

2. Selected theoretical problems - the overview

2.1. Enterprise sustainable development- definition

Sustainable development is a response to the degradation of the natural environment. Its assignment is to protect the environment and counteract climate change to preserve natural resources for present and future generations (Pieloch-Babiarz et al., 2021; Udemba et al., 2021; George et al., 2022). States, institutions, organizations, households and enterprises must cooperate to protect the natural environment.

SD means implementing its basic economic goal and supplementing it with issues related to taking care of its operation's social and environmental standards. It is de-fined in three key areas, ecological (preserving the environment and its natural re-sources), economic (maximizing the profit and wealth of owners through technological progress and increasing the efficiency of the use of raw materials, materials and hu-man work) and social (improving the living conditions and safety of people) (Table 1) (Pickering et al., 2022; Kaul et al., 2022; Ashraf, 2020).

Table 1.
The sustainable development of enterprises- definition

Author	Sustainable development- definition
J. Elkington (1998)	Focus not only on maximizing profits, but equally on environmental and social issues
G. Hilson, B. Murcka (2000)	It is based on three pillars: economic, social and environmental, and entails implementing innovations and modern technologies
A. Wilkinson (2001)	Sustainability includes the ethical dimension and the trade-off's fairness between current economic pressures and future environmental needs
T. Dyllick, K. Hockerts (2002)	Meeting the needs of a firm’s direct and indirect stakeholders (…) without compromising its ability to meet the needs of future stakeholders as well
M.E. Porter, M.R. Kramer (2002)	Take decisions considering the common value
M. Drljača (2012)	A process in which less and fewer resources are being spent to meet the needs of consumers and in which the environment is less polluted
G.F. Dias (2015)	Sustainable development is a way for companies and governments to reverse the negative effects caused by the economic growth model
P. Taticchi, M. Demartini (2021)	Sustainable development of companies is an integral approach to business aimed at strengthening competitive advantage and profitability through the sustainable creation of shared value due to close cooperation with all stakeholders and the integration of ESG factors in the decision-making process
A.J. Costa (2022)	The concept of sustainable development should apply to the external environment of the organization, in other words to a certain region (country, state) in a certain period of time

Source: own elaboration based on the literature on the subject.

The sustainable development of enterprises is a complex issue that requires a holistic approach. In the literature on the subject, there are several definitions of SD. It can be defined as meeting the needs of current and future stakeholders of the company (Dyllick et al., 2002). It also means achieving success today and ensuring its potential in the future (Colbert, Kurucz, 2007). SD is taking decisions considering the common value (Porter, Kramer, 2007). SD is a process aimed at reducing the consumption of resources in order to provide added value for customers and other stakeholders (Drljača, 2012). Sustainable is the company's ability to survive over time, improving its liquidity and profitability, maintaining an appropriate level of debt combined with environmental management and support for employees and local communities (Giovannoni, Fabietti, 2013). SD is a holistic approach to business based on and integrated the social, environmental and economic aspects (Silvestre, Ţîrcă, 2019; Thacker et al., 2019).

2.2. Sustainable development of energy enterprises in the Visegrad Group

Sustainable energy development is a sustainable, safe and effective energy supply process for the countries' economic, social and environmental development. Monitoring the SD should be applicable in assessing the strategy's performance for responsible development (Siksnelyte et al., 2018; Hosseini, 2020).

Energy is the basis for the development of society because the level of its consumption is largely indicative of civilization and technological progress. Energy, on the one hand, increases the quality of life and, on the other, causes the problem of environmental protection to arise and grow. The increasing energy consumption and the wrong structure of its consumption impact the degradation of ecosystems (Hernandez et al., 2019; Siksnelyte et al., 2018).

The socio-economic potential of the region is similar. The main driving factor of the economies is domestic demand and foreign investments, which have been growing in the last two decades. The main differences lie in the economies' size and growth potential. These countries emphasize economic and social issues, while the dynamics of environmental development are lower and recede into the background. These disparities may affect the sustainable development of the energy sector. For example, Slovakia is the only country that has counted on nuclear energy in the past decade (Nyzio, 2017; Kochanek, 2021; Rokicki, Perkowska, 2020).

The energy sector in the Visegrad Group is based mainly on fossil sources, including coal and lignite resources, crude oil and natural gas (Uğurlu, 2022). The share of primary renewable energy is relatively small, but it is expected to have an upward trend (Surwillo et al., 2021). The Czech Republic is accelerating its departure from coal, and its government financially support the development of renewable energy sources. Their approach is changing under the influence of new EU climate targets and rising prices of emission allowances. Slovakia is also accelerating its climate and energy transformation and wants to in-crease the amount of energy obtained from renewable sources and nuclear power. Hungary is also declaring a move away from hard coal. In Poland, on the other hand, discussions are underway on developing energy from renewable sources, although this problem is complex and largely a political decision (Kochanek, 2021; Rokicki, Perkowska, 2020, Kacperska et al., 2021).

A significant problem in the V4 countries is the low level of renewable and green energy sources in developing the energy sector due to the sector's backwardness, systemic transformation, and socio-economic problems (Kacperska et al., 2021; Sulich, Sołoducho-Pelc, 2021). The key barriers to implementing green initiatives are the need for adequate financial resources and the fact that environmental protection is not a priority for the government.

In the V4 countries, one of the critical factors affecting the sustainable development of enterprises is the fact that these countries use European Union funds more effectively and implement green technologies and programs supporting green activities. Economic development is still necessary because it determines investments and eco-logical development (Wach et al., 2021; Uğurlu, 2022; Gostkowski et al., 2021).

Maintaining macroeconomic, social and environmental stability in the last decade is crucial for developing green initiatives (Su et al., 2018; Kiss-Dobronyi et al., 2021). Therefore, it should be emphasized that this relationship should be positive.

Further development of the energy sector in Czechia, Hungary, Poland, and Slovakia should follow the idea of sustainable development, although it will be required large financial outlays in implementing new technologies and removing damage al-ready formed in nature. In implementing new technologies and removing damage al-ready formed in nature.

2.3. Economic, social and environmental situation and sustainable development of energy companies - review of previous research

Numerous scientific analyses are devoted to the relationship between economic growth, legal environment protection regulations, and social conditions for the sustainable development of energy companies. Researchers conduct empirical research, create models of SD of the energy sector (Szczepankiewicz et al., 2022), emphasize the importance of green solutions (Ruiz, Duarte, Fan, 2022), create models of sustainable development (Pereyra-Mariñez et al., 2022; Szczepankiewicz et al., 2022) and conduct theoretical research devoted to analyzing findings on factors affecting sustainable energy (Schwanitz et al., 2022). It is emphasized that both the internal situation of enterprises and the external environment impact the individual pillars of sustainable development (Rosati et al., 2019; Gnanaweera et al., 2018).

In addition, researchers point to the important role of energy economy instruments, including renewable sources, prices of futures contracts for CO2 emissions, outputs on R&D, and the EU Emissions Trading System (Sikora, 2021; Kolosok et al., 2021). These instruments affect investments in the energy sector, innovativeness, and openness to new technical and technological solutions. At the same time, the direction of the impact of these instruments is diverse and may depend on the internal economic conditions in a given country.

According to some researchers, the impact of the market and environmental legal regulations have a variety of consequences on energy productivity (Wahab et al., 2021; Safarzadeh, Rasti-Barzoki, 2019). Moreover, sectoral regulations can hurt energy efficiency (Wang, Chen, Li, 2022, pp. 48539-48557; Wilkinson et al., 2001, p. 12). In developed countries, there is possible that regulatory reforms have contributed to (Komarnicka, Murawska, 2021; Muñoz-Torres et al., 2021) productivity growth in the steam power generation sector (Nakano, Managi, 2010). It is indicated that regulations and provisions should be adapted to the determinants and situation of the energy sector in a particular country.

Most researchers indicate that economic growth and globalization cause an in-crease in the emission of harmful substances into the atmosphere, degradation of the natural environment and the need to increase energy consumption (Tahir et al., 2021; Acheampong et al., 2019).

In turn, macroeconomic, social and environmental stability positively impacts energy companies' sustainable development (Pieloch-Babiarz et al., 2021; Udemba et al., 2021; Comporek et al., 2022). Macroeconomic stability is a configuration of economic indicators corresponding to economic growth conditions.

Social stability means maintaining appropriate proportions in the development of society concerning indicators such as population, health, education, salaries, and social protection expenditure.

Environmental stability can be understood as reducing greenhouse gas emissions, reducing the consumption of raw materials and access to water, reducing the production and consumption of chemicals and preserving biodiversity.

The countries' economic, social and environmental situation should have an impact on the sustainable development of the energy sector. Moreover, this relationship should be positive because improving the quality and living conditions is conducive to undertaking ecological activities.

3. Research methodology

The main aim of our research is to assess the impact of macroeconomic, social and environmental stability on the sustainable development of energy enterprises in the Visegrad Group (the Czech Republic, Hungary, Poland and Slovakia) from 2008 to 2020. We focus on the period from the economic crisis through economic growth until the Covid-19 pandemic. The Visegrad Group was established in 1991 and is an association of four Central European countries - Poland, the Czech Republic, Slovakia and Hungary, aiming to deepen cooperation between these countries.

Our study supplements the literature on the subject with an assessment of the impact of macroeconomic, social and environmental stability on the sustainable development of the energy sector. In addition to introducing the definitions of these concepts, we present a new approach to determining these indicators. **The central research hypothesis (H)** is as follows:

There is a large variation in the strength and direction of the impact of macroeconomic, social and environmental stabilization in the Visegrad Group between 2008 and 2020.

This research approach results from the fact that these countries that have undergone economic transformation need to catch up compared to the west of the European Union. Hence the fundamental decisions concern strictly economic issues, and social issues and environmental protection recede into the background.

We also formulate the following sub-hypothesis:

- **1 Sub-hypothesis (H1):** In the Visegrad Group, SD increased from 2008-2020;
- **2 Sub-hypothesis (H2):** The macroeconomic stability, social and environmental stability have a positive trend line, but it decreased during the Covid-19 pandemic;
- **3 Sub-hypothesis (H3):** The impact of macroeconomic, social and environmental stability on the pillars of sustainable development, economic (E), social (S) and environmental (Env) varies in the countries.

The research includes the following steps:

1) We create indicators: E, S, Env, SD. We considered numerous research and created these factors based on own, proprietary approach.

Collecting analytical indicators and grouping them into three pillars of SD, including:

- E: stimulants: enterprises (number), turnover or gross premiums written (EUR 1 million), → production value (mil euro), → value added at factor cost (EUR 1 million), gross operating surplus (EUR 1 million), total purchases of goods and services (EUR 1 million), gross investment in tangible goods (EUR 1 million), → investment rate (%); and destimulants: cost level index from total activity (%);
- S: stimulants: wages and salaries (EUR 1 million), social security costs (EUR 1 million), employees: number, apparent labour productivity, gross value added per employee (EUR 1000), investment per person employed (EUR 1000), employer's social charges as a percentage of personnel costs: percentage (%), expenditure on training and courses. Destimulants: personnel costs (EUR 1 million), share of personnel costs in production (%), accidents at work;
- Env: destimulants: carbon dioxide, methane nitrous oxide, hydrofluorocarbones (CO2 equivalent), sulphur oxides (SO2 equivalent), carbon monoxide, ammonia.

We transform the explanatory variables into integrated, using the following formulas:

$$E_{ij};\ S_{ij}; Env_{ij} = \sum_{i=1}^{n}\frac{xij}{\max xij} + \sum_{i=1}^{n}\frac{\min xij}{xij};\ E_{ij};\ S_{ij}; Env_{ij} \in [0;1] \quad (1)$$

where:

E_{ij}; S_{ij}; Env_{ij} stands for the normalized value of the *j*-th variable in the *i*-th year,

x_{ij} is the diagnostic variable in *i*-year,

SD_i indicates integrated variable in *i*-year.

We use the following formula to create the SD:

$$SD = E + S + Env = \sum_{i=1}^{n}\frac{E_{ij}}{n} + \sum_{i=1}^{n}\frac{S_{ij}}{n} + \sum_{i=1}^{n}\frac{Env_{ij}}{n}; SD \in [0;1] \quad (2)$$

2) We created MSP, SSP and EnvSP (Figure 1) indicators based on formula (3), (4) and (5).

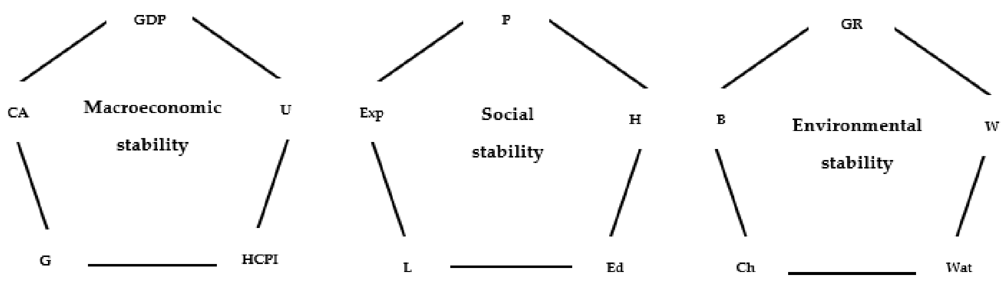


Figure 1. Macroeconomic stability, social stability, environmental stability.
Source: own elaboration.

$$MSP= [(\Delta GDP\cdot U)+(U\cdot HICP)+(HICP\cdot G)+(G\cdot CA)+(CA\cdot \Delta GDP)]\cdot k \quad (3)$$

where:
GDP - gross domestic product,
U - unemployment rate,
HICP - Harmonised Indices of Consumer Prices,
G - government deficit,
CA - current account,
$k = \frac{1}{2}\sin 72° = 0{,}475.$

$$SSP= [(\Delta P\cdot H)+(H\cdot Ed)+(Ed\cdot L)+(L\cdot Exp)+(Exp\cdot \Delta P)]\cdot k \quad (4)$$

where:
P - number of population,
H - healthy life year,
Ed - expenditure on education,
L – wages,
Exp - social protection expenditure,
$k = \frac{1}{2}\sin 72° = 0{,}475.$

$$EnvSP= [(\Delta GR\cdot W)+(W\cdot Wat)+(Wat\cdot Ch)+(Ch\cdot B)+(B\cdot \Delta GR)]\cdot k \quad (5)$$

where:
GR - greenhouse gases emission,
W - generation of waste,
Wat - water made available for use,
Ch - production and consumption of chemicals,
B – biodiversity,
$k = \frac{1}{2}\sin 72° = 0{,}475.$

3) We examine the strength and direction of a linear relationship between the SD and MSP, SSP, and EnvSP. To do this, we use Pearson's R, Spearman-s Rho, Gamma and Kendall rank correlation coefficients. We adopt the following ranges of correlation strength: |rxy| = 0—no correlation; 0 <|rxy| ≤ 0.19—very weak; 0.20 ≤ |rxy| ≤ 0.39—weak; 0.40 ≤ |rxy| ≤ 0.59—moderate; 0.60 ≤ |rxy| ≤ 0.79—strong; 0.80 ≤ |rxy| ≤ 1.00—very strong.
4) We use the OLS method to estimate models, which is given by equation:

$$SD = \propto_0 + \propto_1 \cdot MSP + \propto_2 MSP_{(t-1)} + \propto_3 \cdot SSP + \propto_4 \cdot SSP_{(t-1)} + \propto_5 \cdot EnvSP + \propto_6 \cdot EnvSP_{(t-1)} + \varepsilon_i \quad (6)$$

where:
β_0 is the intercept,
β_1, β_2, β_3 is the slope,
ε_i denotes the *i*-th residual,
i is an observation index.

5) We create the structural equation model and use the SUR method to estimate it:

$$\begin{cases} E = \hat{\beta}_0 + \hat{\beta}_1 MSP_i + \hat{\beta}_2 SSP_i + \hat{\beta}_3 EnvSP_i + \hat{\beta}_4 S + \hat{\beta}_5 Env + e_i \\ S = \hat{\beta}_0 + \hat{\beta}_1 MSP_i + \hat{\beta}_2 SSP_i + \hat{\beta}_3 EnvSP_i + \hat{\beta}_4 E + \hat{\beta}_5 Env + e_i \\ Env = \hat{\beta}_0 + \hat{\beta}_1 MSP_i + \hat{\beta}_2 SSP_i + \hat{\beta}_3 EnvSP_i + \hat{\beta}_4 E + \hat{\beta}_5 S + e_i \end{cases} \quad (7)$$

4. Research results

Table 2 presents SD in the Visegrad Group from 2008 to 2020. All countries show a positive trend, which is a favourable situation. The activities in the Visegrad Group from 2008 to 2020 undertaken for the sustainable development of energy enterprises are effective. The highest dynamics of SD is in Poland (SD = 0.0159 time + 0.6204). Hungary has the lowest dynamics of SD (SD = 0.001 time + 0.7267). The highest average level of SD in the period from 2008 to 2020 is in Poland and Hungary (mean = 0.73), and the lowest average level is in Slovakia (mean = 0.68). The maximum level of SD is in Poland (0.85, 2020), and the minimum is in Slovakia (0.62, 2008).

The highest level of the average SD is in Poland and Hungary because the energy sector has been undergoing a deep transformation for several years related to reducing the general share of conventional energy based on coal in favour of new technologies, particularly energy from renewable sources. In turn, the lowest average level of the SD indicator in Slovakia may be because, in recent years, this country has focused on nuclear energy; thus, the indicator level after 2020 should significantly improve.

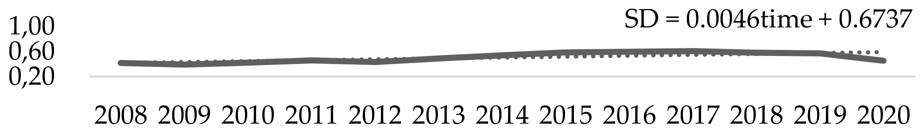
Table 2.
The sustainable development of energy enterprises indicator in the Visegrad Group from 2008 to 2020

Czechia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,64	0,67	0,72	0,73	0,74	0,73	0,68	0,70	0,64	0,69	0,72	0,75	0,76

Descriptive statistics

Mean	Sd	Median	Min	Max
0,71	0,04	0,72	0,64	0,76



Hungary

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,72	0,73	0,75	0,74	0,73	0,73	0,72	0,73	0,73	0,72	0,73	0,76	0,75

Descriptive statistics

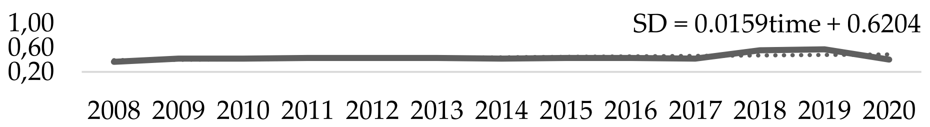
Mean	Sd	Median	Min	Max
0,73	0,01	0,73	0,72	0,76

Poland

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,67	0,65	0,69	0,67	0,68	0,69	0,72	0,75	0,73	0,76	0,80	0,85	0,85

Descriptive statistics

Mean	Sd	Median	Min	Max
0,73	0,06	0,72	0,65	0,85

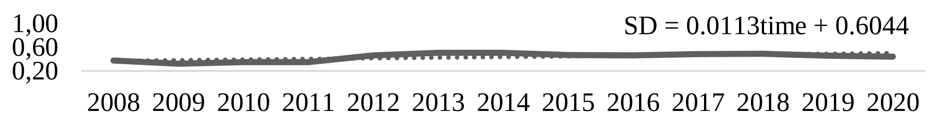


Slovakia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,62	0,64	0,66	0,62	0,67	0,66	0,74	0,67	0,67	0,68	0,73	0,76	0,77

Descriptive statistics

Mean	Sd	Median	Min	Max
0,68	0,05	0,67	0,62	0,77



Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 3 shows MSP in the Visegrad Group from 2008 to 2020. All countries show a positive trend. The policy in the Visegrad Group from 2008 to 2020 undertaken for the macroeconomic stabilization of energy enterprises is efficient. The highest dynamics of MSP are in Czechia (MSP = 0.0143 time + 0.4037). The lowest dynamics of MSP is in Hungary (MSP = 0.0021time + 0,5162). The highest average level of MSP from 2008 to 2020 is in Hungary (mean = 0.53), and the lowest is in Poland and Slovakia (mean = 0.44). The maximum level of MSP is in Chechia (0.61, 2017), and the minimum is in Slovakia (0.32, 2009).

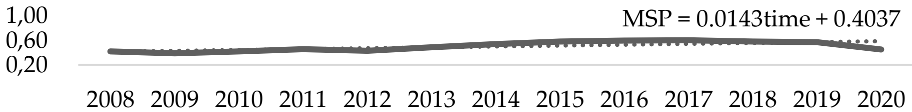
Table 3.
The macroeconomic stability indicator in the Visegrad Group from 2008 to 2020

Czechia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,42	0,39	0,42	0,46	0,43	0,49	0,54	0,58	0,60	0,61	0,58	0,57	0,45

Descriptive statistics

Mean	Sd	Median	Min	Max
0,50	0,08	0,49	0,39	0,61

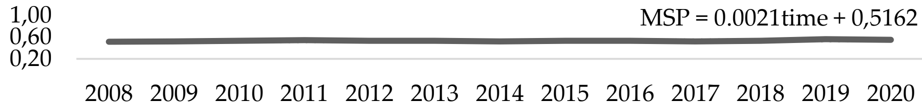


Hungary

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,51	0,52	0,53	0,54	0,53	0,53	0,52	0,53	0,53	0,52	0,53	0,56	0,55

Descriptive statistics

Mean	Sd	Median	Min	Max
0,53	0,01	0,53	0,51	0,56

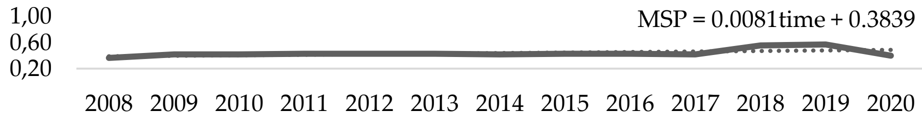


Poland

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,37	0,42	0,42	0,43	0,43	0,43	0,42	0,43	0,43	0,42	0,56	0,57	0,40

Descriptive statistics

Mean	Sd	Median	Min	Max
0,44	0,06	0,43	0,37	0,57

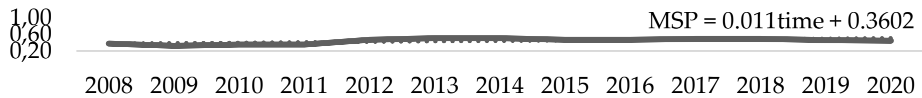


Slovakia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,38	0,32	0,35	0,35	0,46	0,50	0,51	0,47	0,46	0,49	0,49	0,46	0,44

Descriptive statistics

Mean	Sd	Median	Min	Max
0,44	0,06	0,46	0,32	0,51



Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 4 presents SSP in the Visegrad Group from 2008 to 2020. In Czechia, Hungary and Poland is a positive trend. The policy in these countries from 2008 to 2020 undertaken for the social stability of energy enterprises is effective. The highest dynamics of SSP are in Hungary (SSP = 0.0076 time + 0.439). The lowest dynamics of SSP is in Czechia (SSP = 0.0004time + 0.4562). In Slovakia is a negative trend (SSP = -0.0024time + 0.5166), which points to the need for increased attention to social stability in this country. The highest average level of SSP in the period from 2008 to 2020 is in Slovakia (mean = 0.50), and the lowest average level is in Czechia (mean = 0.46). The maximum level of SSP is in Hungary (0.57, 2019), and the minimum is in Hungary (0.40, 2020).

Table 4.
The social stability indicator in the Visegrad Group from 2008 to 2020

Czechia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,44	0,45	0,45	0,46	0,47	0,48	0,47	0,47	0,46	0,45	0,46	0,46	0,45

Descriptive statistics

Mean	Sd	Median	Min	Max
0,46	0,01	0,46	0,44	0,48

Hungary

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,41	0,44	0,46	0,47	0,48	0,49	0,51	0,52	0,53	0,56	0,57	0,57	0,40

Descriptive statistics

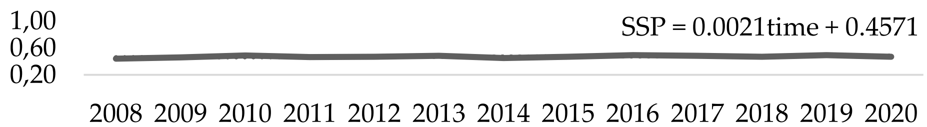
Mean	Sd	Median	Min	Max
0,49	0,05	0,49	0,40	0,57

Poland

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,44	0,46	0,49	0,46	0,47	0,48	0,45	0,47	0,49	0,48	0,47	0,49	0,47

Descriptive statistics

Mean	Sd	Median	Min	Max
0,47	0,02	0,47	0,44	0,49

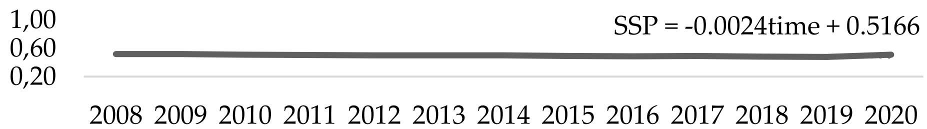


Slovakia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,52	0,52	0,51	0,50	0,50	0,50	0,50	0,49	0,49	0,49	0,48	0,48	0,51

Descriptive statistics

Mean	Sd	Median	Min	Max
0,50	0,01	0,50	0,48	0,52



Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 5 shows EnvSP in the Visegrad Group from 2008 to 2020. In Czechia, Hungary and Poland is a positive trend. The activities in these countries from 2008 to 2020 undertaken for the environmental stability of energy enterprises brought positive results. The highest dynamics of EnvSP is in Czechia (EnvSP = 0.0036 time + 0.3645). The lowest dynamics of SSP are in Hungary (EnvSP = 0.0015 time + 0.452). In Slovakia is a negative trend (EnvSP = -0.0018 time + 0.5043), which means that attention should be paid to improving environmental stability in this country. The highest average level of EnvSP in the period from 2008 to 2020 is in Slovakia (mean = 0.49), and the lowest average level is in Czechia (mean = 0.39). The maximum level of EnvSP is in Slovakia (0.51, 2012, 2013), and the minimum is in Czechia (0.35, 2008).

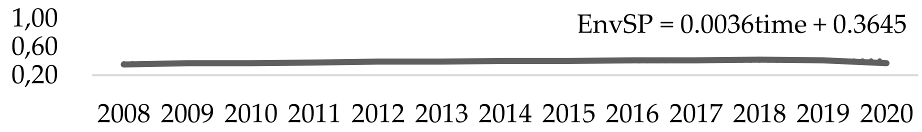
Table 5.
The environmental stability indicator in the Visegrad Group from 2008 to 2020

Czechia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,35	0,37	0,37	0,38	0,39	0,39	0,40	0,40	0,41	0,41	0,42	0,41	0,37

Descriptive statistics

Mean	SD	Median	Min	Max
0,39	0,02	0,39	0,35	0,42

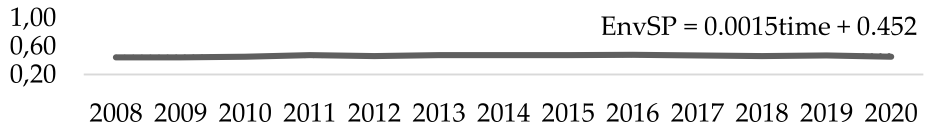


Hungary

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,44	0,44	0,45	0,47	0,46	0,47	0,47	0,48	0,48	0,47	0,46	0,47	0,45

Descriptive statistics

Mean	SD	Median	Min	Max
0,46	0,01	0,47	0,44	0,48



Poland

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,41	0,45	0,44	0,46	0,45	0,46	0,44	0,46	0,46	0,47	0,48	0,48	0,45

Descriptive statistics

Mean	SD	Median	Min	Max
0,45	0,02	0,46	0,41	0,48

Slovakia

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0,48	0,49	0,50	0,50	0,51	0,51	0,50	0,50	0,49	0,48	0,48	0,48	0,48

Descriptive statistics

Mean	SD	Median	Min	Max
0,49	0,01	0,49	0,48	0,51

Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 6 presents the Pearson's R, Spearman-s Rho, Gamma and Kendall rank correlation coefficients between SD and MSP, SSP and EnvSP in the Visegrad Group from 2008 to 2020. There is a positive or negative relationship between these variables and different levels of correlation coefficients regarding the strength of impact. The strong or very strong correlation is bolded in the table ($p < 0.05$). The highest positive level of correlation is in Hungary (Gamma = 0.96, between SD and MSP), and the lowest positive level of correlation is in Poland (Gamma and Kendall rank = 0.44, between SD and SSP). The highest negative level of correlation is in Slovakia (Spearman-s Rho = -0.62, between SD and SSP), and the lowest is in Slovakia (Gamma, Kendall rank = -0.49, between SD and SSP).

Table 6.
The Pearson's R, Spearman-s Rho, Gamma and Kendall rank correlation coefficients in the period from 2008 to 2020, p < 0.05 (n = 13)

Country	Correlation	SD		
		MSP	**SSP**	**EnvSP**
Czechia	Pearson's R	-0.06	0.27	0.14
	Spearman-s Rho	-0.02	0.24	0.08
	Gamma	-0.05	0.19	0.07
	Kendall rank	-0.05	0.18	0.07
Hungary	Pearson's R	**0.88**	-0.08	-0.07
	Spearman-s Rho	**0.92**	0.05	-0.01
	Gamma	**0.96**	0.03	-0.01
	Kendall rank	**0.86**	0.03	-0.01
Poland	Pearson's R	**0.55**	0.40	0.53
	Spearman-s Rho	0.26	**0.59**	0.55
	Gamma	0.26	**0.44**	**0.47**
	Kendall rank	0.23	**0.44**	**0.47**
Slovakia	Pearson's R	0.55	-0.49	-0.53
	Spearman-s Rho	0.46	**-0.62**	-0.46
	Gamma	0.31	**-0.49**	-0.38
	Kendall rank	0.31	**-0.49**	-0.38

Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 7 shows the results of the OLS regressions between SD and MSP, MSP(t-1), SSP, SSP(t-1), EnvSP, and EnvSP(t-1) in the Visegrad Group from 2008 to 2020. The results of the OLS estimation include no autocorrelation, collinearity, homoscedasticity, and normal distribution of variables. The relationship between the examined variables is positive or negative, with a different level of strength.

In all countries, in the period from 2008 to 2020, the MSP (or MSP(t-1)) and En-vSP (or EnvSP(t-1)) influence SD, the SSP (or SSP(t-1)) has an influence on SD only in Czechia and Hungary. The highest positive level of relationship is in Czechia (3.480, between SD and EnvSP(t-1)), and the lowest positive level of relationship is in Hungary (0.036, between SD and SSP(t-1)). The highest negative level of relationship is in Slovakia (−3.368, between SD and EnvSP(t-1)), and the lowest negative level of relationship is in Hungary (−0.086, between SD and SSP).

The coefficient determination ranges from 0.739 (Slovakia, which means a satisfactory fit to the model's data) to 0.985 (Hungary, a very good fit to the model's data).

Table 7.
The Results of the OLS regressions in the period from 2008 to 2020 (p < 0.05):
$SD = \propto_0 + \propto_1 \cdot MSP + \propto_2 \cdot MSP_{(t-1)} + \propto_3 \cdot SSP + \propto_4 \cdot SSP_{(t-1)} + \propto_5 \cdot EnvSP + \propto_6 \cdot EnvSP_{(t-1)} + \varepsilon_i$

Country	Independent variable	Coefficient	Std. error	p-value	R^2
Czechia	const	0.156	0.242	0.5441	0.920
	MSP	−0.320	0.116	0.0324	
	$MSP_{(t-1)}$	−0.445	0.155	0.0287	
	SSP	1.346	0.685	0.0472	
	$SSP_{(t-1)}$	−2.255	0.682	0.0163	
	$EnvSP_{(t-1)}$	3.480	0.493	0.0004	
Hungary	const	0.455	0.073	0.0004	0.985
	MSP	0.868	0.046	<0.0001	
	SSP	−0.086	0.014	0.0004	
	$SSP_{(t-1)}$	0.036	0.013	0.0269	
	EnvSP	−0.335	0.136	0.0435	
Poland	const	−0.571	0.321	0.1094	0.842
	$MSP_{(t-1)}$	0.879	0.153	0.0003	
	EnvSP	2.003	0.712	0.0203	
Slovakia	const	2.114	0.390	0.0004	0.739
	MSP	0.534	0.137	0.0036	
	$EnvSP_{(t-1)}$	−3.368	0.815	0.0025	

Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

Table 8 presents the results of the SUR estimation between E, S, Env and MSP, SSP, EnvSP, and E, S, Env (depending on the model type) in the Visegrad Group from 2008 to 2020.

In all countries, there is a high differentiation in the factors that affect E, S, and Env. The relationship between the examined variables is positive or negative, with a different level of strength.

In all countries, from 2008 to 2020, Env influences E, and E influences S and Env. The highest positive level of relationship is in Slovakia (3.318, between E and EnvSP), and the lowest is in Poland (0.275, between S and E). The highest negative level of relationship is in Slovakia (−9.639, between Env and EnvSP), and the lowest negative level of relationship is in Czechia (−0.265, between S and MSP).

Table 8.
Results of SUR regressions in the period from 2008 to 2020 (p < 0.05):

$$\begin{cases} E = \propto_0 + \propto_1 \cdot \mathrm{MSP} + \propto_2 \cdot SSP + \propto_3 \cdot \mathrm{EnvSP} + \propto_4 \cdot S + \propto_5 \cdot Env + \varepsilon_i \\ S = \propto_0 + \propto_1 \cdot \mathrm{MSP} + \propto_2 \cdot SSP + \propto_3 \cdot \mathrm{EnvSP} + \propto_4 \cdot E + \propto_5 \cdot Env + \varepsilon_i \\ Env = \propto_0 + \propto_1 \cdot \mathrm{MSP} + \propto_2 \cdot SSP + \propto_3 \cdot \mathrm{EnvSP} + \propto_4 \cdot E + \propto_5 \cdot S + \varepsilon_i \end{cases}$$

Country	Dependent variable	Independent variable	Coefficient	Std. error	p-value	R^2
Czechia	E	const	-1.615	0.299	0.0004	0.725
		SSP	1.654	0.450	0.0058	
		S	1.461	0.209	6.40E-05	
		Env	1.020	0.136	3.71E-05	
	S	const	0.844	0.080	2.29E-06	0.703
		MSP	-0.265	0.078	0.0079	
		E	0.538	0.092	0.0002	
		Env	-0.610	0.101	0.0002	
	Env	const	1.566	0.248	0.0001	0.690
		EnvSP	-1.549	0.489	0.0114	
		E	0.937	0.129	4.63E-05	
		S	-1.402	0.206	7.77E-05	

Cont. table 8.

Hungary	E	const	1.151	0.212	0.0004	0.972
		MSP	2.715	0.263	2.79E-06	
		S	-1.350	0.169	2.27E-05	
		Env	-1.191	0.068	2.91E-08	
	S	const	0.864	0.097	8.99E-06	0.958
		MSP	1.790	0.279	0.0001	
		E	-0.655	0.082	2.27E-05	
		Env	-0.825	0.057	1.57E-07	
	Env	const	1.005	0.141	5.48E-05	0.990
		MSP	2.231	0.240	6.50E-06	
		E	-0.820	0.047	2.91E-08	
		S	-1.171	0.081	1.57E-07	
Poland	E	const	0.165	0.094	0.1070	0.546
		Env	0.805	0.127	5.37E-05	
	S	const	0.494	0.117	0.0014	0.512
		E	0.275	0.154	0.0021	
	Env	const	-0,124	0.136	0.3814	0.546
		E	1.135	0.178	5.37E-05	
Slovakia	E	const	-1.010	0.531	0.0864	0.440
		EnvSP	3.318	1.028	0.009	
		Env	0.288	0.073	0.0029	
	S	const	1.419	0.242	0.0001	0.367
		E	-0.930	0.307	0.0115	
	Env	const	3.563	0.791	0.0015	0.810
		MSP	1.002	0.282	0.0063	
		EnvSP	-9.639	1.635	0.0002	
		E	1.672	0.393	0.0021	

Source: own study on the basis of Eurostat https://ec.europ a.eu/Eurostat, 1.02.2023.

The coefficient determination ranges from 0.367 (Slovakia, which means an unsatisfactory fit to the model's data) to 0.972 (Hungary, which means a very good fit to the model's data).

5. Discussion

Sustainable development of enterprises takes place in strictly defined socio-economic conditions. Like most researchers, we underline that it is a complex and holistic idea and depends on internal and external factors (Pieloch-Babiarz et al., 2021; Udemba et al., 2021; Dias, 2015; Taticchi, Demartini, 2021; Costa et al., 2022).

Our research results are in line with research conducted so far in the field of sustainable development of energy companies in the V4 countries. Similarly to other researchers, we obtained results indicating positive, small dynamics of sustainable development of energy enterprises and their diversification in the surveyed countries (Sulich et al., 2021; Kacperska et al., 2021; Wach et al., 2021; Uğurlu, 2022; Gostkowski et al., 2021).

The correlation results indicate that the level of statistically significant correlation is different and small between SD and SME, SSP and EnvSP. In the Czech Republic, there was no statistically significant relationship. In turn, the correlation coefficients are statistically significant between SD and SME in Hungary (the level of dependence is high), in Poland between SD and SSP, but the level is at an average level, and between SD and EnvSP, and in Slovakia between SD and SSP. Sustainable development of the energy sector in these countries, therefore, also depends on other factors, including geopolitical conditions and the current policy of the state authorities (Drljača, 2012; Giovannoni, Fabietti, 2013; Silvestre, Ţîrcă, 2019; Thacker et al., 2019).

The central research hypothesis is true because the impact of different dimensions on SD varies in strength and direction. The results of the OLS estimation indicate that all dimensions of stability have a statistically significant impact on SD. Moreover, there are relationships between the values of stabilization indicators from the previous period. The direction and strength of these relationships vary. The largest number of indicators affect SD in the Czech Republic and Hungary, while in Poland, SD is affected by MSP(t-1), EnvSP, and in Slovakia, MSP and EnvSP(t-1). One of the most important factors is macroeconomic stabilization (Udemba et al., 2021; Comporek et al., 2022; Cader et al., 2021), and therefore the governments of these countries should implement a stable monetary and fiscal policy, stimulate economic growth and ensure an appropriate level of employment.

The first research sub-hypothesis is true. Therefore, let us confirm the results of research to date, which indicate that the sustainable development of energy enterprises has small growth dynamics. The highest level of dynamics of sustainable development of energy enterprises was observed in Poland and the lowest in Hungary. Across all countries, there was a slight decline in sustainability in the year the Covid-19 pandemic began. We confirm other researchers' analyses which show that the Covid-19 pandemic hurts economic and social development (Kacperska et al., 2021; Sulich et al., 2021).

We can confirm the second research sub-hypothesis because, from 2008 to 2020, there were positive dynamics of macroeconomic stabilization in all countries as well as social and environmental stability (Slovakia is an exception). However, it should be emphasized that the general socio-economic situation in Slovakia is good, although the Covid-19 pandemic has resulted in a slight increase in unemployment and a decrease in economic activity.

We also accept the third research sub-hypothesis. The results of the SUR estimation indicate a large variation in the impact of macroeconomic, social and environmental stability on the filters of sustainable development of energy companies (economic, social and environmental) in the Visegrad countries. We have noticed that the individual pillars are, to a different extent, dependent on each other, so social or environmental development affects economic development and vice versa. In Poland, social and social development is influenced by economic development and economic development by environmental development. On the other hand, in other countries, the basic element affecting E, S and Env is MSP, i.e. there is a statistically significant relationship between macroeconomic decisions and the development of the energy sector.

Our models can help to formulate the theoretical and practical implications. They have limitations related to the selection of analytical indicators for models, the method of determining indicators, the research period, or the research sample itself. Nevertheless, it is important both from the point of view of decisions made by enterprises and economic practice.

Our research allows us to indicate important theoretical and empirical implications. Theoretical implications include the creation of an original definition of sustainable development and, reviewing the literature on the subject, developing an indicator assessment and models of sustainable development. Among the empirical implications, one should distinguish those that are important for national policy and those for business managers. From the state's point of view, a more responsible environmental policy should be implemented, actions should be taken to change the energy balance, and the development of renewable energy sources should be supported. The energy policy should neutralize or limit the risks associated with potential crises in the country and internationally; this is also part of the implementation of the main goal of the energy policy, i.e. guaranteeing energy security while ensuring the competitiveness of the economy and reducing the impact of the energy sector on the environment. In addition, good economic and social situations should be used to implement renewable energy sources. The research results are important for the managers of enterprises because they must consider issues related to their financial and property situation and analyze macroeconomic indicators, social issues and environmental protection regulations.

The direction of development of policies supporting sustainable development should be coordinated with economic, social and environmental policies. What is more, these countries are forced to focus on renewable and anatomic energy sources in the current geopolitical conditions.

The results of our research indicate that the energy sector in the analyzed countries is developing gradually (Silvestre, Ţîrcă, 2019; Thacker et al., 2019; Rokicki, Perkowska, 2020; Uğurlu, 2022). It is necessary to introduce reforms, change energy policy and transform economies to alternative energy sources (Siksnelyte et al., 2018; Kochanek, 2021). Energy transformation is especially important in the historical moment in which the region is connected with the Ukraine war. It is necessary to take political action, reform the energy sector and implement innovative solutions.

6. Conclusions

The sustainable development of energy enterprises in the Visegrad Group countries has a slight positive trend, which is a positive phenomenon. It is necessary to implement reforms aimed at developing alternative energy sources. We have noted that macroeconomic, social and environmental stabilization impact on sustainable development varies in the countries surveyed, which may indicate that their socioeconomic and environmental potentials are different.

Theoretical implications include the introduction of its definition of sustainable development of enterprises, social and environmental stability and the created econometric models. The empirical implications include that the research results can support state managers and enterprises in their development strategies.

Further research will be devoted to analyzing the sustainable development of energy companies in developed countries in the European Union, and we will conduct comparative analyses between countries.

Abbreviations

SD - sustainable development of energy enterprises.
E - economic development of energy enterprises.
S - social development of energy enterprises.
Env - environmental development of energy enterprises.
MSP - macroeconomic stability.
SSP - social stability.
EnvSP - environmental stability.
GDP - gross domestic product.
U - unemployment rate.
HICP - Harmonised Indices of Consumer Prices.
G - government deficit.
CA - current account.
H - healthy life year.
Ed - expenditure on education.
L - wages.
Exp - social protection expenditure.
GR - greenhouse gases emission.
W - generation of waste.
Wat - water made available for use.
Ch - production and consumption of chemicals.
B - biodiversity.

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