SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 195

THE ECONOMIC INSTRUMENTS AND MACROECONOMIC STABILIZATION ON THE DECARBONIZATION OF CENTRAL AND EASTERN EUROPEAN COUNTRIES

Magdalena KOWALSKA[1*], Anna MISZTAL[2]

[1] Faculty of Economics and Sociology, University of Lodz; magdalena.kowalska@uni.lodz.pl, ORCID: 0000-0002-5821-0305
[2] Faculty of Economics and Sociology, University of Lodz; anna.misztal@uni.lodz.pl, ORCID: 0000-0002-7455-5290
* Correspondence author

Purpose: This paper aims to assess the impact of energy economic instruments and macroeconomic stabilization on decarbonization in the Central and Eastern European Countries (CEECs) from 2005 to 2019. The central research hypothesis (H) is "The impact of economic instruments and macroeconomic stabilization on decarbonization varies in the Central and Eastern European Countries from 2005 to 2019".
Design/methodology/approach: We use the Ordinary Least Squares (OLS) to verify our hypothesis.
Findings: The impact of economic instruments is varied. The most effective instruments are the EU Emissions Trading System, outlays on renewable energy sources, and futures contracts for CO2 emissions.
Research limitations/implications: The availability of data, the choice of normalization method and the choice of estimation method for both the one-equation model.
Practical implications: The results show that economic instruments and macroeconomic stabilization have a positive impact on the decarbonization of economies, hence shaping their appropriate level is important for sustainable development.
Social implications: Economic instruments impact on decarbonization and thus improve the quality of life.
Originality/value: The impact of economic instruments is varied. The most effective instruments are the EU Emissions Trading System, outlays on renewable energy sources, and futures contracts for CO2 emissions.
Keywords: economic instruments, macroeconomic stabilization, decarbonization.
Category of the paper: research paper.

1. Introduction

To ensure Changing the global energy mix is crucial to ensure appropriate conditions and quality of life for the present and future generations (Månberger, 2018; Sachs et al., 2019). The energy transformation and the "green deal" help develop renewable energy sources, create new markets and workplaces in energy sectors, improve energy efficiency, and reduce carbon dioxide emissions. A key challenge is decarbonization, which systematically reduces carbon dioxide (CO2) emissions to the atmosphere. It shifts the economy to zero-emission or low-emission energy sources and helps stop global warming (Habert et al., 2020; Stef, Ben Jabeur, 2020).

Economic instruments play a significant role in decarbonization because they, directly and indirectly, impact on the environmental strategies and decisions made by enterprises, households, and public institutions. Their main aim is to reduce the emission of harmful substances into the environment. Additionally, the effectiveness of decarbonization depends on macroeconomic stabilization, which is a challenge for states' economic policy (Mazzanti, Ugo Rizzo, 2017; Peñasco et al., 2021).

This paper is empirical, and its main aim is to assess the impact of economic instruments and macroeconomic stabilization on decarbonization in the Central and Eastern European Countries (CEECs) from 2005 to 2019. Moreover, we want to examine the strength and direction of the impact between the variables. We focus on eleven countries, which are developing economies, and they started in the last few years the transformation of their energy system. The research period covers the years from 2005, the time of accession to the European Union and the possibility of full use of European funds and policies.

A novelty in the research is assessing the impact of energy economic instruments on decarbonization, which also consider the macroeconomic stabilization for their effectiveness in reducing the emission of harmful substances to the environment. The issues raised are paramount and, at the same time, relatively poorly researched. There is a lack of research on the impact of economic instruments and macroeconomic stabilization on decarbonization in the CEECs. Such analyzes are extremely important for acting and implementing policies to reduce CO2 emissions.

To verify the central hypothesis, "The impact of economic instruments and macroeconomic stabilization on decarbonization varies in the Central and Eastern European Countries from 2005 to 2019", we use the Ordinary Least Squares (OLS). We created a decarbonization indicator (DeCO2), the macroeconomic stabilization pentagon (MSP) and assessed the impact of economic instruments such as financial outlays on environmental protection (x1), environmental taxes (x2), outlays on renewable energy sources (x3), prices of futures contracts for CO2 emissions (x4), outlays on R&D (x5), EU Emissions Trading System (EU ETS) (x6), and macroeconomic stabilization on decarbonization. The selection of variables for the model is limited to the instruments of the energy economy. Thus, we overlook other important economic instruments such as credits, loans, and mutual funds.

The presented models have serious limitations. Undoubtedly, the results are influenced by the choice of indicators for analysis, but it can support economic decisions that respect the climate aspect. The model will also help identify which instruments are more effective from the decarbonization process and what changes could be made to the selected instruments to make them more decarbonized.

2. Conceptual background

Carbon reduction, energy supply stability, and energy efficiency are factors for the prosperity, security, and development of modern economies. Decarbonization is the systematic reduction of carbon dioxide (CO2) emissions to the atmosphere. It requires the use of renewable energy sources, modernization of energy infrastructure, support for sustainable transport, investments in research and development, urban regeneration, modernization of technology, and eco-innovations (Mateusz, Wojciechowski, 2012; Jenniches, 2018; Verburg et al., 2019; Louche et al., 2019).

Although decarbonization requires certain financial outlays on the modernization of economies, the benefits of reducing CO2 emissions to the atmosphere are undeniable to the environment, climate and living conditions (Gouldson et al., 2018; Papadopoulou et al., 2020; Simionescu et al., 2021). Decarbonization requires implementing regulations, plans, skills, and financial support tools (Rivera, 2020; Kolosok et al., 2021).

Economic instruments, or more specifically energy economic instruments, play an important role in decarbonization. They, directly and indirectly (through the financial factors: costs and prices), impact enterprises' decisions and strategies. They can be positive (subsidies, tax breaks or excise duties, rates depreciation, preferential loans, R&D) or negative (taxes on energy or pollution, emissions trading). Economic tools are based largely on the principle that polluters should cover external costs (the polluter pays) (Mazzanti, Ugo Rizzo, 2017; Peñasco, 2021).

Among the energy economy instruments, we can distinguish financial outlays on environmental protection, environmental taxes, outlays on renewable energy sources, prices of futures contracts for CO2 emissions, outlays on R&D, EU Emissions Trading System.

The development of R&D, renewable energy sources and increasing the financial outlays on environmental protection increase the innovation. It also promotes new models and solutions that reduce harmful substances' emissions into the natural environment. Expenditure on environmental protection should increase in the state budget, and it is also important to maintain macroeconomic stabilization (Månberger, 2018; Sofia et al., 2020; Haldar, Sethi, 2020).

Environmental taxes are crucial to protect the climate, and their base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment (OECD, 2005). It seems that countries implementing environmental policy should strive to increase the share

of environmental taxes in fiscal revenues. However, it is extremely important to define the so-called optimal rates, as their too high level may adversely affect economic growth (Hany, Khaled, 2017; Catalano et al., 2020). Some researchers encourage introducing a global carbon tax to accelerate the decarbonization process (Papadis, Tsatsaronis, 2020; Fajczak-Kowalska et al., 2021).

Futures contracts for CO2 emissions are a market instrument that is influencing carbon dioxide emissions. The higher the future contracts for CO2 emission, the bigger the impact on the energy sector's investment in low-carbon technologies such as wind, solar, and energy efficiency. The low prices of futures contracts for CO2 emissions can be a result of over-licensing in the market. As the research results show, this may be a consequence of the economic crisis and unstable markets.

The Emissions Trading System is an essential element of the European Union's environmental policy, reducing greenhouse gas emissions (Rosendahl, 2019; Flachsland et al., 2020). Firms receive or buy emission allowances to trade according to their needs (within certain limits) (Flachsland et al., 2020). Creating a single market for the environment is a success for the EU. Although EU ETS positively affects decarbonization, several studies show no evidence that the EU ETS caused carbon leakage (Naegele, Zaklan, 2019). Some researchers focus on EU ETS reform and discuss complementing it with a carbon price floor (Hintermayer, 2020).

The tightening EU ETS and the European Green Deal will lead to speeds up transformation by 3-17 years, higher shares of energy from renewable sources, decreases cumulative emissions, only small increases costs. Moreover, fossil, and nuclear unavailability does not affect results (Pietzcker et al., 2021). They also indicate that reforms to the EU ETS are unlikely to achieve their stated objectives in the power and industrial sectors. However, they can reduce emissions proportionally to the minimum requirements (Drummond, Ekins, 2017).

Decarbonization must be accompanied by macroeconomic stabilization (equilibrium in the real and monetary sphere) (Monnin, 2018; Pieloch-Babiarz et al., 2021). What is more, there is a relationship between these two variables. Macroeconomic stabilization is conducive to taking ecologically responsible actions (Brazovskaia et al., 2021). Moreover, macroeconomic stabilization is one of the conditions for the stable development of economies, and it should reduce carbon dioxide emissions to the atmosphere in the long term (Umar et al., 2020).

The choice of economic instruments is crucial for decarbonization, especially in developing countries. The support policy is the main driver of renewable resources diffusion in Europe. The effectiveness of the policy varies by region and by instrument (Bersalli et al., 2020). Some researchers indicate a greater but decreasing impact of price instruments on carbon intensity than renewable energy policies. There is also a visible and greater impact of indirect price signals than explicit ones (Mckibbin, 2017; Raveh, 2020). The analyzes emphasize that economic instruments provide continuous incentives to reduce pollution, even after reaching the normative emission limit.

3. The research methodology

This research aims to assess the impact of economic instruments and macroeconomic stabilization on decarbonization in the CEECs from 2005 to 2019. We analyzed the following economic instruments financial outlays on environmental protection, environmental taxes, outlays on renewable energy sources, prices of futures contracts for CO2 emissions, outlays on R&D, EU Emissions Trading System. It is not a complete list of all instruments for environmental protection, but according to the literature on the subject and economic practice, they are crucial for decarbonization. We also determine the macroeconomic stabilization indicator based on the stabilization pentagon method. The research sample covers the Central and Eastern European Countries, including Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic, and Slovenia. These countries are linked not only by their geographic location but also by history and a similar course of economic transformation. These countries are among the developing countries, with the great importance of fossil fuels for economic development.

The central research hypothesis (H) is "The impact of economic instruments and macroeconomic stabilization on decarbonization varies in the Central and Eastern European Countries in 2005-2019". We use the Ordinary Least Squares to verify our hypothesis. The justification for the research hypothesis is that countries use economic instruments to a different extent, have a different scale of problems related to compliance with nature protection standards, have a different energy balance and a different level of development of industry and new technologies. The research questions are as follows:

- Which of the economic instruments contributes most to decarbonization?
- Are economic instruments optimal, or do they require changes?
- In addition to economic instruments, does macroeconomic stabilization positively or negatively affect decarbonization?

To verify our research hypothesis, we use the Ordinary Least Squares. Our research consists of two stages:

1) Verification of the research hypothesis (H):
   we create two types of models allowing for the assessment of relationships between variables (dependent variables are indicators of decarbonization):
   Model 1:

$$De_{CO2i} = \beta_0 + \beta_1 x_1 + +\beta_2 x_2 + +\beta_3 x_3 + +\beta_4 x_4 + +\beta_5 x_5 + +\beta_6 x_6 + \varepsilon_i$$

   Model 2:

$$De_{CO2i} = \beta_0 + \beta_1 x_1 + +\beta_2 x_2 + +\beta_3 x_3 + +\beta_4 x_4 + +\beta_5 x_5 + +\beta_6 x_6 + \beta_7 MSP_t + \beta_8 t + \beta_9 De_{(t-1)} + \varepsilon_i$$

2) Conclusion and discussion.

We form the indicator of decarbonization. We use the following formula:

$$\mathrm{De_{CO2i}} = \frac{min\mathrm{CO_2}}{\mathrm{CO_{2\,i}}},$$

where:
$CO_{2\,i}$ – emission of carbon dioxide in in the i – year,
De_{CO2i} – the indicator of decarbonization in the i-year,
min CO_2 – minimum value of carbon emissions in 2008-2018.

Then we form the macroeconomic stabilization. We use the formula (Kołodko, 1993):

$$MSP=[(\Delta GDP*U) + (U*CPI) + (CPI*G) + (G*CA) + (CA*\Delta GDP)]*k$$

where:
a = ΔGDP ∗ U ∗ k - presents triangle area called the real sphere triangle and characterizes the relation between the rate of economic growth and unemployment rate;
b = U ∗ CPI ∗ k - stands for the stagflation triangle which depends on the unemployment rate and inflation rate;
c = CPI ∗ G ∗ k - is defined as the budget and inflation triangle;
d = G ∗ CA ∗ k - is called the financial equilibrium triangle and depends on the budget and the current account balance;
e = CA ∗ ΔGDP ∗ k - means the external sector triangle and shows the variability of current account balance and rate of economic growth;
k =1/2 sin 72 = 0.475 - is a constant value.

4. The research results

Figure 1 presents the decarbonization indicator in the period from 2005 to 2019. In all countries (except Lithuania), De_{CO2} characterizes an upward trend (parameters before the time variable are positive). The decarbonization process should be assessed positively, although it is necessary to take further actions aimed at reducing CO2 emissions to the atmosphere. The decline in decarbonization in the period from 2017 to 2020 may result from the growing demand of economies for electricity (for example, in Poland, the production of electricity from hard coal and lignite increased by over 20% in the last year, and unfortunately, production from gas and wind decreased, as well as electricity imports). Moreover, the disturbance may result from the EU regulations forcing countries to reduce carbon dioxide emissions into the atmosphere. These countries slowly began to change their energy balance (e.g. Lithuania and Poland), which may increase decarbonization in the short term. The authorities should focus on shifting from hard coal and investing in renewable energy sources are a priority. All analysed countries should invest in renewable energy sources and implement innovations to increase energy efficiency.

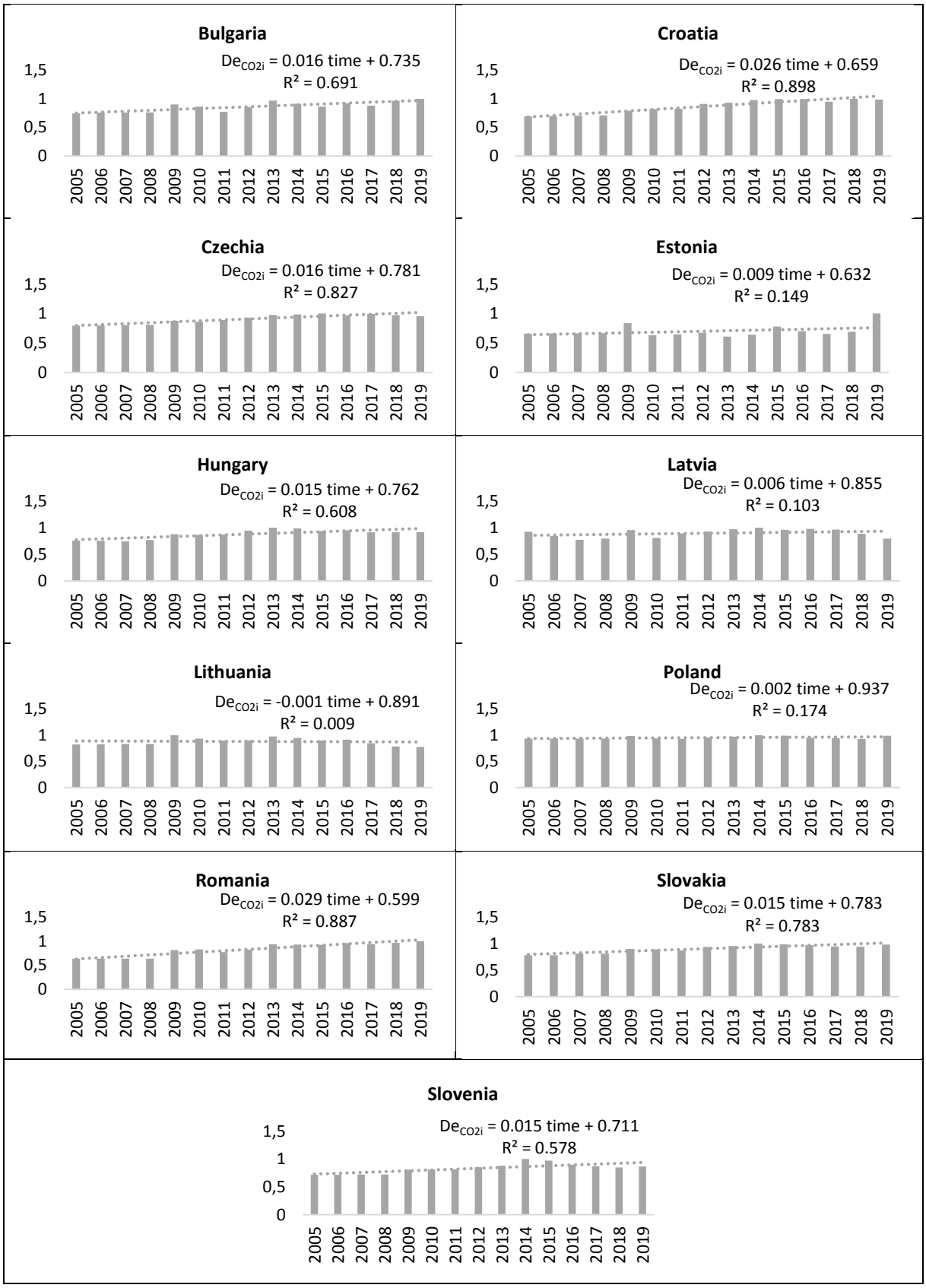

Figure 1. The indicator of decarbonization of CEECs in the period from 2005 to 2019.

Source: own study based on Eurostat [https://ec.europa.eu/Eurostat], 10.12.2020.

Table 1 presents the result of the OLS estimation of Model 1. In all countries, the impact of economic instruments on the indicator of decarbonization is statistically significant and diversified (in terms of strength and direction).

In Czechia, Hungary, and Slovenia, four economic instruments influence the indicator of decarbonization. In other countries, two/three economic instruments influence the indicator of decarbonization. The EU Emissions Trading System is the most common of all economic instruments (in nine countries). The least common economic instrument is outlaid on R&D (only in one country, which means that R&D expenditure is low). The coefficient of determination ranges from 0.669 (a satisfactory fit to the model's data) to 0.988 (a perfect fit to the model's data).

The estimation results show that the EU instruments are crucial for decarbonizing the countries in Eastern Europe. In the studied countries, we obtain different models, indicating that they vary in energy balance, R&D level, and industry structure. In most cases, there is a statistically significant influence of external economic tools on decarbonization. It is necessary to create restrictive legal, environmental regulations at the EU level, which affect decisions made in the Member States under the threat of financial penalties.

Table 1.

Results of Ordinary Least Squares regression method in the CEECs in the period from 2005 to 2019: $De_{CO2i} = \beta_0 + \beta_1 x_i + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \varepsilon_i$

Country	Dependent variable	Independent variable	Coefficient	p - value	R^2
Bulgaria	De_{CO2i}	constant	0.551	2.09e-07 ***	0.809
		x_1	0.001	0.0202 **	
		x_3	0.024	0.0002 ***	
Croatia	De_{CO2i}	constant	1.444	3.52e-015 ***	0.972
		x_4	−0.002	0.060 *	
		x_6	−5.503e-08	1.15e-09 ***	
Czechia	De_{CO2i}	constant	1.204	<0.0001 ***	0.988
		x_2	−3.027e-05	0.0324 **	
		x_4	−0.004	<0.0001 ***	
		x_5	0.001	0.0002 ***	
		x_6	−3.807e-09	0.0031 ***	
Estonia	De_{CO2i}	constant	1.151	<0.0001 ***	0.907
		x_2	0.001	0.0046 ***	
		x_6	−4.084e-08	<0.0001 ***	
Hungary	De_{CO2i}	constant	1.296	<0.0001 ***	0.972
		x_2	−5.819e-05	0.0374 **	
		x_3	0.043	0.0588 *	
		x_4	−0.003	0.0482 **	
		x_6	−1.524e-08	0.0214 **	
Latvia	De_{CO2i}	constant	1.312	<0.0001 ***	0.789
		x_1	−0.001	0.0686 *	
		x_4	−0.007	0.0041 ***	
		x_6	−9.868e-08	0.0344 **	
Lithuania	De_{CO2i}	constant	0.865	<0.0001 ***	0.669
		x_1	0.001	0.0135 **	
		x_4	−0.007	0.0016 ***	

Cont. table 1.

Poland	De_{CO2i}	constant	1.462	<0.0001 ***	0.689
		x_2	−1.040e-05	0.0235 **	
		x_3	0.013	0.0173 **	
		x_6	−2.248e-09	0.0155 **	
Romania	De_{CO2i}	constant	1.130	<0.0001 ***	0.978
		x_3	0.010	0.0029 ***	
		x_6	−8.697e-09	<0.0001 ***	
Slovakia	De_{CO2i}	constant	0.887	<0.0001 ***	0.980
		x_1	0.001	0.0531 *	
		x_3	0.034	<0.0001 ***	
		x_6	−1.387e-08	0.0039 ***	
Slovenia	De_{CO2i}	constant	1.065	<0.0001 ***	0.980
		x_1	0.001	0.0011 ***	
		x_3	0.005	0.0736 *	
		x_4	−0.004	0.0003 ***	
		x_6	−4.818e-08	<0.0001 ***	

Source: own study based on Eurostat [https://ec.europa.eu/Eurostat], Investing [https://www.investing.com/], IEA [https://www.iea.org/], Our World in Data [https://ourworldindata.org/], EEA [https://www.eea.europa.eu/], 9.04.2021.

Table 2 presents the results of the estimation of the Model 2. In each country, apart from Slovakia (problems with economic growth, unemployment, and foreign trade after the economic crisis), there is a statistically significant positive impact of macroeconomic stabilization on decarbonization. This result means that the existence of stable economic equilibrium is of key importance for environmental policy. The introduction of the macroeconomic stabilization indicator also influences the change of statistically significant economic instruments influencing decarbonization. Moreover, in Bulgaria, Czechia, Latvia, and Romania, the estimation results indicate the impact of decarbonization from the previous period on the current reduction of carbon dioxide emissions to the atmosphere. In other words, it means a certain continuity in the decarbonization of these countries.

Table 2.

Results of Ordinary Least Squares regression method in CEECs in the period from 2005 to 2019: $De_{CO2i} = \beta_0 + \beta_1 x_1 + +\beta_2 x_2 + +\beta_3 x_3 + +\beta_4 x_4 + +\beta_5 x_5 + +\beta_6 x_6 + \beta_7 MSP_t + \beta_8 t + \beta_9 De_{(t-1)} + \varepsilon_i$

Country	Dependent variable	Independent variable	Coefficient	p - value	R^2
Bulgaria	De_{CO2i}	constant	2,288	0,0155 **	0,999
		x_1	0,002	0,0252 **	
		x_2	−0,002	0,0294 **	
		x_3	−0,008	0,0748 *	
		x_4	0,018	0,0317 **	
		x_5	0,002	0,0327 **	
		x_6	−2,4e-08	0,0131 **	
		MSP	1,490	0,0282 **	
		t	0,042	0,0332 **	
		$De_{(t-1)}$	−0,432	0,0438 **	
Croatia	De_{CO2i}	constant	1,493	<0,0001 ***	0,974
		x_1	−0,001	0,0851 *	
		x_6	−5,9e-08	<0,0001 ***	
		MSP	0,365	0,0046 ***	

Cont. table 2.

Czechia	De_{CO2i}	constant	1,717	<0,0001 ***	0,999
		x_1	0,001	<0,0001 ***	
		x_2	−0,001	<0,0001 ***	
		x_3	0,012	0,0001 ***	
		x_4	0,000	0,0013 ***	
		x_6	-2,1E-09	0,0002 ***	
		MSP	0,213	<0,0001 ***	
		t	0,020	<0,0001 ***	
		$De_{(t-1)}$	−0,537	<0,0001 ***	
Estonia	De_{CO2i}	constant	1,274	<0,0001 ***	0,986
		x_2	0,001	0,0117 **	
		x_6	−4,7e-08	<0,0001 ***	
		MSP	0,210	<0,0001 ***	
Hungary	De_{CO2i}	constant	1,933	<0,0001 ***	0,959
		x_3	−0,058	0,0046 ***	
		x_6	−3,7e-08	<0,0001 ***	
		MSP	0,156	0,0041 ***	
Latvia	De_{CO2i}	constant	2,623	0,0039 ***	0,999
		x_1	−0,001	0,0209 **	
		x_2	0,001	0,067 *	
		x_3	−0,009	0,0127 **	
		x_4	−0,018	0,009 ***	
		x_6	−1,1e-07	0,01 **	
		MSP	2,387	0,0149 **	
		t	0,045	0,0414 **	
		$De_{(t-1)}$	−0,332	0,0245 **	
Lithuania	De_{CO2i}	constant	1,026	<0,0001 ***	0,772
		x_1	−0,030	0,0278 **	
		x_4	−0,008	0,0029 ***	
		MSP	1,002	0,0380 ***	
Poland	De_{CO2i}	constant	1,521	<0,0001 ***	0,800
		x_1	0,001	0,092 *	
		x_2	−2,5e-05	0,0066 ***	
		x_6	−2,9e-09	0,0089 ***	
		MSP	0,438	0,0089 ***	
Romania	De_{CO2i}	constant	1,545 ***	<0,0001	0,999
		x_2	−1,9e-05 *	0,0647	
		x_3	0,003 *	0,0819	
		x_4	0,003 **	0,0159	
		x_6	−1,e-08 ***	<0,0001	
		MSP	0,371 ***	0,0046	
		$De_{(t-1)}$	−0,146 **	0,0155	
Slovakia	De_{CO2i}	constant	2,241	<0,0001 ***	0,974
		x_2	−0,001	0,0574 *	
		x_4	−0,002	0,0337 **	
		x_6	−1,2e-07	<0,0001 ***	
		MSP	−0,292	0,0262 **	
Slovenia	De_{CO2i}	constant	1,051	<0,0001 ***	0,974
		x_3	0,022	0,0086 ***	
		x_6	−1,8e-08	0,0008 ***	
		MSP	0,241	0,0164 **	

Source: own study based on Eurostat [https://ec.europa.eu/Eurostat], Investing [https://www.investing.com/], IEA [https://www.iea.org/], Our World in Data [https://ourworldindata.org/], EEA [https://www.eea.europa.eu/], 9.04.2021.

The OLS estimation results indicate that the impact of economic instruments and the macroeconomic situation on decarbonization is different in Eastern Europe. Decarbonization and macroeconomic situation are interrelated in developing economies. In addition, the EU instruments, including the EU Emission Trading System, are necessary for reducing emissions of harmful substances in the eastern EU countries. The European Union's regulations, rules and environmental protection plans are essential for the decarbonization of the member states. Therefore, the external impact, based on the polluter pays principle, brings the best results.

5. Discussion

Instruments of energy economy are important, although they are not the optimal solution. They allow only to reduce CO2 emissions to the atmosphere and not eliminate the whole emission of harmful substances. These instruments should be considered in the context of the country. The impact of economic instruments on decarbonization varies across the countries studied, as these countries differ in size, level of development and economic structure and have different energy balances. Importantly, these countries have different possibilities of implementing eco-innovation, and their energy consumption is different.

The research results show that the economic instruments decreased the carbon dioxide emissions to the atmosphere. Thus, we confirm the previous research, highlighting the importance of energy economy instruments for decarbonizing developing countries (Mazzanti, Ugo Rizzo, 2017; Peñasco et al., 2021). Moreover, the impact of the instruments on decarbonization vary across the countries. The instrument that appears most frequently in the research results is the EU Emissions Trading System. These results confirm that the EU ETS is a crucial component of the EU's climate change policy and its primary tool to reduce greenhouse gas emissions cost-effectively.

We agree with other researchers who also point to the importance of the EU ETS (Naegele, Zaklan, 2019; Hintermayer, 2020; Pietzcker, 2021). However, we would like to point out that this instrument still needs to be reformed (the direction of the current reforms seems correct), and a more comprehensive approach to environmental protection among business managers is necessary. Entrepreneurs must develop strategies and business models that take environmental considerations into account. Otherwise, they will be forced to incur high financial expenses related to the functioning of the EU emissions trading system. In addition to the EU ETS, contracts for CO2 emissions and environmental taxes are essential for decarbonization. Like other authors, we have noted their contribution to reducing carbon dioxide emissions (Catalano, 2020; Papadis, Tsatsaronis, 2020; Fajczak-Kowalska et al., 2021). However, it seems to us that these instruments are still not fully used.

Model shows the positive impact of macroeconomic stabilization on decarbonization in most emerging and developing economies in the eastern European Union (the exception here is Slovakia, where an increase in macroeconomic stabilization leads to a decrease in decarbonisation, it may result from macroeconomic problems in this country, especially with economic growth, unemployment rate, internal demand after the economic crisis) (Issah, Antwi, 2017; Pieloch-Babiarz et al., 2021).

Adding the decarbonization indicator, variable "time", and decarbonization from the previous period to the model slightly changes the results, but the general direction of the impact is like in the first two models. The research results indicate that it was possible to separate economic growth from decarbonization in the analyzed countries (Boţa-Avram et al., 2018; Wang et al., 2019). Moreover, maintaining macroeconomic stabilization is essential for eco-investment and environmental activities (Owen et al., 2018; Wang, Zhang, 2018).

6. Conclusions

Economic instruments play an important role in decarbonization. We can distinguish financial outlays on environmental protection, environmental taxes, outlays on renewable energy sources, prices of futures contracts for CO2 emissions, outlays on R&D, and the EU Emissions Trading System. This list is not exhaustive of all instruments and tools, but it seems that these play a fundamental role in reducing carbon dioxide emissions.

The research results indicate that countries manage in reducing carbon dioxide emissions. Statistical models indicate that the central research hypothesis is true because "The impact of economic instruments and macroeconomic stabilization on decarbonization varies in the Central and Eastern European Countries from 2005 to 2019".

The models show that the EU Emissions Trading System is important for decarbonization in nine of eleven countries (Croatia, Czechia, Estonia, Hungary, Latvia, Poland, Romania, Slovakia, Slovenia). In six countries, outlays on renewable energy sources (Bulgaria, Poland, Hungary, Romania, Slovenia, and Slovenia) and futures contracts for CO2 emissions (Croatia, Czechia, Hungary, Latvia, Lithuania, Slovenia) are essential for decarbonization. The outlays on environmental protection are important for reducing the CO2 in five countries (Bulgaria, Latvia, Lithuania, Slovakia, Slovenia) and environmental taxes in four countries (Czechia, Estonia, Hungary, and Poland). On the other hand, outlays on R&D have a statistically significant impact only in Czechia. Moreover, the strength and direction of the impact between the variables are different.

There is also a statistically significant impact of macroeconomic stabilization on decarbonization. Moreover, in most countries, this dependence is positive, which means that the macroeconomic policy goes hand in hand with decarbonization. Hence, a rational and stable

policy aimed at economic growth, a decline in unemployment, and maintaining inflation at an appropriate level is indispensable.

Economic instruments seem to have a positive effect on decarbonization, but they are not optimal. It seems necessary to take rational measures to rebuild the economics in hand with protecting the natural environment. In the short term, it is necessary to stimulate domestic demand and take radical political action. It also seems that the change in the approach to environmental taxes is justified. Taking measures to increase their share in total fiscal revenues is crucial for climate protection and sustainable development.

The EU Emissions Trading System stimulates investment into clean, low-carbon technologies. After recovering from the crisis caused by the covid pandemic, a principal challenge will be to increase prices to force companies to invest in new, environmentally friendly technologies. For example, launching financial programs encouraging investments in renewable energy sources. Decarbonization requires radical political decisions which should focus on the reorganization of industry and closing mines.

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