Comparative Economic Research

Central and Eastern Europe

Volume 27 No. 2/2024

WYDAWNICTWO UNIWERSYTETU ŁÓDZKIEGO

WYDZIAŁ EKONOMICZNO-SOCJOLOGICZNY Uniwersytet Łódzki

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Łódź 2024

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Uniwersytet Łódzki

COPE
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JM13708

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Printed directly from camera-ready materials provided to the Lodz University Press

Journal affiliated with the Faculty of Economics and Sociology of the University of Lodz

Published by Lodz University Press
First Edition. W.11446.24.0.C
Printing sheets 25.0

ISSN 1508-2008
e-ISSN 2082-6737

Lodz University Press
90-237 Łódź, 34A Matejki St.
www.wydawnictwo.uni.lodz.pl
e-mail: ksiegarnia@uni.lodz.pl
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Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.10

Comparing Links between Topic Trends and Economic Indicators in the German and Polish Academic Literature

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Abstract

The popularity of econometric analyses that include variables obtained from text mining is growing rapidly. A frequently applied approach is to identify topics from large corpora, which makes it possible to determine trends that reflect the changing relevance of topics over time. We address the question of whether such topic trends are linked to quantitative economic indicators typically used for analysing the objects described by a topic. The analysis is based on academic economic articles from Poland and Germany from 1984 to 2020. There is a specific focus on whether relationships between topic trends and indicators are similar across national economies. The connection between topic trends and indicators is analysed using vector autoregressive models and Granger causality tests.

Keywords: topic modelling, text analysis, latent Dirichlet allocation, Granger causality, topic trends

JEL: C49

Received: 18.04.2023. Verified: 21.09.2023. Accepted: 4.04.2024

Introduction

The popularity of analyses that include variables obtained from texts in econometric models is growing rapidly. Identifying topics in large corpora is often done as it makes it possible to determine trends that reflect the changing relevance of topics over time. Such trends might provide information about economic developments, and they can subsequently be used as (additional) indicators in economic analyses. Therefore, we determine whether topic trends obtained from academic text corpora from Poland and Germany might be linked to quantitative economic indicators typically used for analysing the objects described by a topic. The textual data cover the period 1984–2020. Given the different developments in Poland and Germany during this period, we are particularly interested in whether the relationships between topic trends and indicators were similar across national economies. Consequently, we focus on topics which are common to both text corpora.

The underlying textual data concern empirical economics and applied statistics (the German text collection) and econometric modelling in general (the Polish text collection). Given these specific characteristics of the two corpora, the uncovered topics are either associated with economic phenomena or the methods used to analyse them. The relative interest over time in both categories of topics can be potentially linked to real economic processes as certain developments can directly motivate the discussion in the literature and be reflected in the changing popularity of particular methods or frameworks of doing the analysis. Since the first type of link might be more pronounced, and as themes related to methods or theory found for both collections of texts were quite general, we focus on topics with macroeconomic content in this contribution.

The goal of the analysis is twofold. Firstly, we provide further evidence that the results of topic modelling, i.e. uncovered latent topics and topic weight time series, can be used in the next step to study the links between real developments and the popularity of topics in a given text corpus. This type of result provides new insights for describing a text collection. Secondly, we compare the links between interest in topics common to Polish and German text corpora and developments in the national and global economies. Thereby, given the differences between the corpora and the economies considered, it is not obvious how many common topics can be identified. The paper contributes to the literature on the links between textual data and real indicators by considering topics which were discussed in texts published in two countries and by providing results of causality tests for both countries.

Establishing links between textual data and quantitative economic indicators has been the subject of analysis in the past, with fast-growing interest during the last few years. Thereby, one may differentiate between keyword and sentiment-based methods and approaches that focus on identifying topics. Examples of the first group are the uncertainty

index proposed by Baker, Bloom, and Davis (2016) and, more recently, the fiscal sentiment indicator discussed by Latifi et al. (2023). Our contribution belongs to the second group, which also includes papers on using topic modelling in the context of innovation activities by Venugopalan and Rai (2015) and Bergeaud, Potiron, and Raimbault (2017). They analysed the classification of patents based on patent applications, though without an explicit focus on the time dimension. Furthermore, Lenz and Winker (2020) extracted innovation-related topics from news-ticker data and generated a time series of topic weights linked to fields on innovations. With a similar approach, Savin, Ott, and Konop (2022) provide an analysis of diffusion for different types of service robots.

Papers more closely related to our research compare times series of topic weights with quantitative economic indicators. Lüdering and Winker (2016) studied the dynamic links between the relevance of topics in academic publications and the development of corresponding macroeconomic indicators between 1949 and 2010 for Germany. Additionally, Hansen, McMahon, and Prat (2017) analysed the impact of increased transparency on monetary policy using publications of the Federal Open Market Committee. Dybowski and Adämmer (2018) used a topic model to analyse fiscal policy in the US, while Huang et al. (2018) and Larsen and Thorsrud (2022) considered the dynamic links between topic importance and financial market outcomes. Thorsrud (2020) and Ellingsen, Larsen and Thorsrud (2022) used related approaches to exploit textual data from newspapers to improve GDP forecasts.

The structure of the article is as follows. Section 2 presents the German and Polish text corpora, topics found using latent Dirichlet allocation, a topic-matching procedure, and real economic indicators. Section 3 describes time series methods used to analyse the relations between topic trends and economic indicators. The results on the links of topics and real economic developments are provided in Section 4. A summary of the central findings and suggestions for further work are given in Section 5.

Textual and economic data

The analysis is based on two different types of data: textual data, in the form of academic research articles, and standard economic variables. While the textual data must be transformed into quantitative indicators by means of topic modelling, the challenge regarding the economic indicators involves selecting appropriate series that correspond to the topics identified based on the textual data. The two types of data are described in the following two subsections.

Transforming text to time series

The text corpora comprise research papers in the field of economics and econometrics published from 1984 to 2020 in Germany and Poland. For Germany, we use all original articles from the Journal of Economics and Statistics (JES)[1], which were published mainly in German during the first half of the sample, then with an increasing share in English, reaching almost 100% towards the end of the sample. For Poland, we combine contributions to the proceedings of the Macromodels International Conference (MM) until 2011 and the Central European Journal of Economic Modelling and Econometrics (CEJEME) after 2009. Detailed descriptions of both text corpora can be found in Bystrov et al. (2022).

While the scope of both academic outlets is international, we observe that contributions discussing issues related to the German and Polish economies, respectively, constitute considerable shares of articles over the sample period. This is the rationale for contrasting the results from topic modelling with national as well as global economic indicators. Furthermore, given the low frequency of publications (six issues per year for JES, one for MM and four for CEJEME), the following analysis will be done at an annual level. Thereby, we also alleviate the problem of publication lags inherent both in conference contributions and even more so in journal publications. We will return to this issue in the discussion of the Granger causality analysis in Section 4.

The first step in transforming the text corpora into quantitative indicators involves applying a latent Dirichlet allocation (LDA) model to both corpora (Blei, Ng, and Jordan 2003). For details on pre-processing, parameter choice, and the handling of the multilingual German corpus, see again Bystrov et al. (2022). The LDA estimation results provide topics discussed in the text corpora and their relative weights, which change over time. These weights correspond to the topic time series, which are considered in the subsequent analysis.

The model selection step for the LDA indicated 37 and 60 topics for the Polish and German corpora, respectively. The larger number of different topics for the German dataset is plausible, given the broader scope of JES compared to MM and CEJEME. In further analysis, we focus on topics and their corresponding weight time series, which are relevant in both corpora. Common themes were identified using the topic-matching method proposed by Bystrov et al. (2022), which is based on a comparison of topic distributions over a joint vocabulary. Topic resemblance is evaluated using the cosine similarity measure, and the matching is done by finding the nearest neighbour of a topic estimated for one corpus in the other corpus. The pairs which are considered reasonable matches are selected based on a cut-off value for the cosine similarity measure, i.e.,

1 For a previous application of topic modelling to articles published in this journal see Lüdering and Winker (2016).

only matches with a high enough cosine similarity are kept. For the present application, this threshold was set to 0.265, resulting in 24 topics appearing in both corpora. The labels of the topics were assigned based on the inspection of the corresponding word clouds available in Bystrov et al. (2022) and the documents with the highest weights for the particular topic.

For further analysis, we restrict the set of topics to those that correspond to applied economic research, which might be more closely related to specific economic developments than the dynamics of topics related to purely methodological or theoretical research in economics, econometrics and statistics, such as forecasting, simulation methods or welfare economics. Furthermore, our focus is on the national economy level. Therefore, we chose topics that describe macroeconomic relationships rather than processes at the micro level, such as firm growth or household income. Appendix A.1 provides information on the topics which were rejected. Table 1 below lists the remaining topics, the corresponding cosine similarity values, and the economic indicators chosen as described in the following subsection.

Table 1. Summary of common topics and selected economic indicators

Topic label	Proposed indicator	Cosine similarity
International economics	Trade share	0.86 146
Banking and credit	Credit-to-GDP ratio	0.85 116
Business cycle	Output gap	0.83 445
Capital and growth	Growth rate of investment	0.80 610
Labour market	Unemployment rate	0.72 227
Crude oil market	Oil market shocks	0.70 459
Monetary policy	Policy rate	0.69 914
Stock market	Stock market return, stock price volatility	0.63 251
Foreign trade	Net export share	0.49 535
Energy sector	Total primary energy production	0.48 663

Source: authors' own elaboration.

Selecting economic indicators

The selection of economic indicators related to the topics shown in Table 1 is based on the interpretation of these topics and considering related articles with the highest weights. Furthermore, this selection must consider data availability for both countries over the sample period. The specific sources and available samples of these economic time series are summarised in Table 3 in Appendix A.2.

Given the structure of textual resources, all data are annual. This frequency of observations is appropriate for considering links between real developments and their discussion in journal and conference articles, as publication lags or time for researching a new topic might be considerable.

While for most of the topics a suitable observable economic indicator is assigned for both the German and the Polish economies, the setting is different for the topic that refers to the crude oil market. In this case, a suitable indicator would be one of the shocks to the international oil market. Given that such an indicator cannot be observed directly, it must be derived first using an auxiliary model. To this end, we use the method proposed by Kilian (2009). Then, given that global oil market shocks are considered, the same time series of shocks is used in the analysis of the Polish and German data. A more detailed discussion of the variables listed in Table 1 follows in Section 4, together with the results of Granger causality testing.

Methods

The quantitative analysis is based on vector autoregressive models (VARs), which are a natural choice if the aim is to test for (Granger) causality when the direction of causality is not known a priori. We use bivariate VAR models, where one of the variables is the weight of a topic aggregated over all documents for each period. We label these series topic weight series. The second variable is the economic indicator linked to the specific model. A two-dimensional VAR(p) is given by the following formula (see Kilian and Lütkepohl 2017):

$$y_t = \nu + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + B d_t + u_t, \tag{1}$$

where $y_t = (topic_t, ind_t)'$ is the vector of topic weight and economic indicator in period t. The parameter matrices $A_i (i = 1, \ldots, p)$ have dimensions 2×2, ν is a two-dimensional intercept vector, d_t includes all remaining necessary deterministic terms like dummy variables or trends with the corresponding parameters gathered in matrix B, and u_t is a two-dimensional vector of error terms.

Prior to estimation, variables included in the model are differenced if the results of the augmented Dickey-Fuller (ADF) test indicate the presence of a unit root. Furthermore, to consider the trending and nonlinear behaviour of topic weights, which can be observed in some cases, vector d includes the deterministic trend t and the second power of this variable in selected models. The lag order of the VAR, $\hat{p}$, is chosen using the Akaike information criterion (AIC), applying a maximal lag length of 4 years.

The models are tested for autocorrelation and autoregressive conditional heteroskedasticity (ARCH) effects of the error terms. Information on data transformations, the use of deterministic variables (apart from the intercept), and the selected lag order of the VAR for all the models are provided in Tables 5 and 6 in Appendix A.2.

In the last step, to check for dynamic links between economic indicators and topic trends, Granger causality tests are performed. The hypothesis of instantaneous causality is also tested. If autocorrelation or ARCH errors are detected, these tests are based on the heteroskedasticity- and autocorrelation-consistent (HAC) estimator of the variance matrix for the ordinary least squares (OLS) (see Table 6 in Appendix A.2 for the type of estimator used). The significance level for Granger causality tests is set to $\alpha = 0.1$. The outcomes of the tests may be to detect no causality, causality in one direction, or causality in both directions. If the topic weights prove to be Granger causal for the real economic indicators, this implies that changes in discussion intensity of the topic in the academic literature preceded relevant economic developments. The opposite outcome indicates that relevant developments in parts of the economy led to a more intensive academic discussion of these aspects afterwards. If Granger causality is found for both directions, both channels are relevant, i.e., specific economic developments are accompanied by a change in the relevance of the topic in science, both ex-ante and ex-post. While Granger causality focuses on the dynamic interlink between variables, it does not cover mutual influences taking place within one period, i.e., one year. Such contemporaneous effects are reflected by a significant correlation of the error terms of the VAR model across equations and are often labelled instantaneous causality. Given the low frequency of our data, instantaneous causality might comprise links that would be measured as Granger causality at a higher frequency. This effect could be quite pronounced as academic publications and conference proceedings were published with substantial publication lags for the period considered in our empirical application. Therefore, we also report the results of the tests of instantaneous causality.

Results

In this section results of the Granger causality analysis are presented for the selected topics common to the JES and MM/CEJEME text corpora as described in Section 2. Figures 1 and 2 present the distribution of the relative topic importance for both corpora, that is measured by computing the mean of topic weights over the sample period. The topics are ordered in descending order according to their relative importance for the respective corpora. The bars in orange represent "matched" topics, meaning that they are common for both countries, as identified by Bystrov et al. (2022) (see subsection 2.1). Correspondingly, the bars in blue represent "unmatched" topics, meaning that these topics are specific to a single corpus. Dashed orange bars highlight topics

selected for further analysis within the VAR models together with corresponding economic indicators (see Table 1 in Section 2).

The outcomes of the Granger causality testing are summarised in Table 2. These results are discussed in more detail for each topic separately in the following subsections. Word clouds for all the topics are shown in Figure 3.

Capital and growth

The topic of capital and growth was relatively important in both the MM/CEJEME and JES corpora. Average weights amounted to 0.0472 and 0.0354, respectively, which meant that it was the 4th and the 10th most discussed theme in respective text collections. The time series of topic weights were modelled together with an economic indicator given by the growth rate of gross fixed capital formation. Statistical tests (see Table 2) indicated Granger causality from the economic indicator to topic weights for the Polish texts and two-way Granger causality for the German corpus.

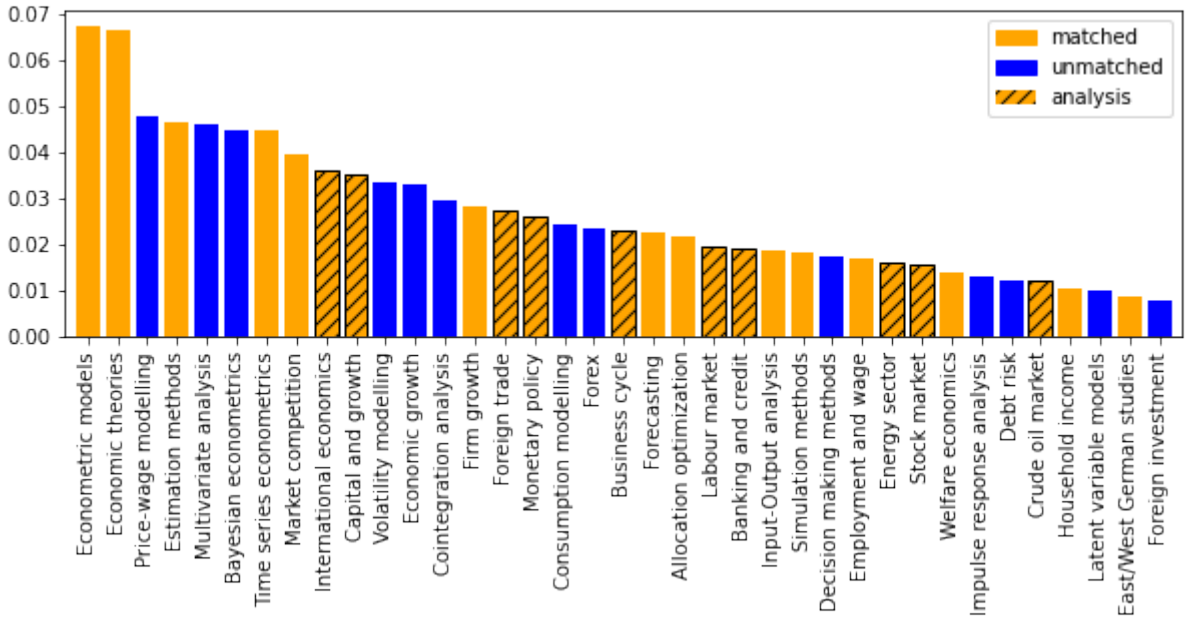

Figure 1. Relative topic importance for Poland

Source: authors' own elaboration.

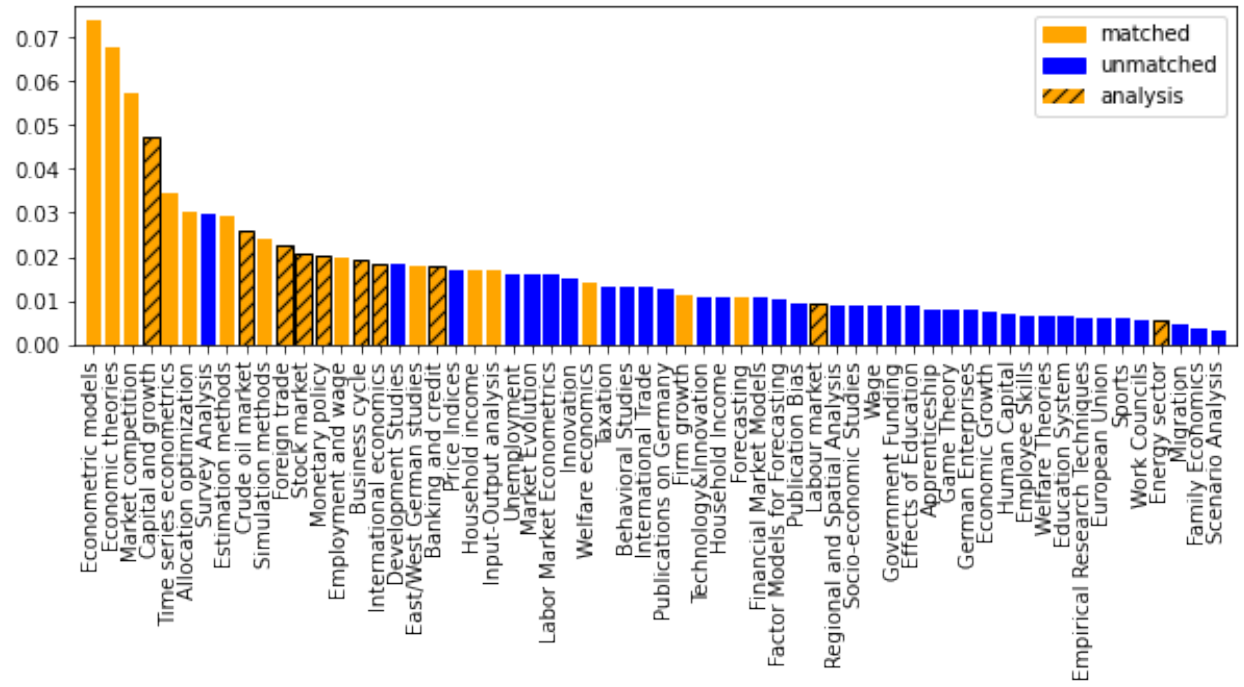

Figure 2. Relative topic importance for Germany

Source: authors' own elaboration.

Table 2. Granger causality test results

Topic label	Economic indicator	Country	Hypothesis:		
			The topic weight is not a Granger cause for the economic indicator	The economic indicator is not a Granger cause for the topic weight	No instantaneous causality
Capital and growth	Growth rate of gross fixed capital formation	Poland	1.5933 [0.2114]	**2.4496 [0.0763]**	0.7304 [0.4710]
		Germany	**2.3099 [0.0470]**	**4.3290 [0.0226]**	−0.5192 [0.6071]
International economics	Trade share	Poland	0.2718 [0.6069]	**3.0073 [0.0951]**	−0.7904 [0.4362]
		Germany	0.0314 [0.8605]	0.4400 [0.5122]	−1.2610 [0.2162]
Foreign trade	Share of net exports in GDP	Poland	**9.4156 [0.0005]**	**13.790 [0.0001]**	**−3.2370 [0.0034]**
		Germany	**7.3949 [0.0007]**	1.9984 [0.1317]	−0.5633 [0.5774]
Monetary policy	Policy rate	Poland	1.2599 [0.2719]	**4.2389 [0.0497]**	−0.3062 [0.7616]
		Germany	0.3366 [0.5658]	**3.7268 [0.0622]**	0.6340 [0.5303]
Business cycle	Output gap	Poland	1.6602 [0.2094]	0.1777 [0.6770]	−0.5225 [0.6054]
		Germany	2.1504 [0.1192]	1.1875 [0.3346]	−0.5355 [0.5960]
Crude oil market	Oil supply shocks	Poland	0.0835 [0.7746]	0.2850 [0.5972]	**3.0807 [0.0041]**
		Germany	1.3461 [0.2543]	1.3274 [0.2576]	0.4892 [0.6278]

Topic label	Economic indicator	Country	Hypothesis:		
			The topic weight is not a Granger cause for the economic indicator	The economic indicator is not a Granger cause for the topic weight	No instantaneous causality
Crude oil market	Aggregate demand shocks	Poland	1.4327 [0.2404]	0.0710 [0.7916]	– 1.0949 [0.2813]
		Germany	1.9530 [0.1716]	**3.3648 [0.0756]**	1.3285 [0.1929]
Crude oil market	Oil specific-demand shocks	Poland	0.3835 [0.5402]	**3.7426 [0.0622]**	– 0.8218 [0.4169]
		Germany	0.0748 [0.7862]	2.0362 [0.1630]	0.4259 [0.6728]
Banking and credit	Credit-to GDP ratio	Poland	2.1402 [0.1565]	1.0865 [0.3076]	– 1.0753 [0.2925]
		Germany	0.0670 [0.7975]	**7.0072 [0.0125]**	– 0.6651 [0.5106]
Stock market	Stock market return	Poland	0.3974 [0.5349]	0.2459 [0.6249]	– 0.4490 [0.6576]
		Germany	**5.3744 [0.0280]**	0.3702 [0.5478]	1.5390 [0.1346]
Stock market	Stock price volatility	Poland	**8.5297 [0.0022]**	**15.8720 [0.0002]**	– 0.1086 [0.9146]
		Germany	1.0500 [0.3140]	1.9445 [0.1738]	– 0.3685 [0.7151]
Labour market	Unemployment rate	Poland	0.4140 [0.5256]	0.1316 [0.7197]	**4.8774 [0.0000]**
		Germany	2.3394 [0.1153]	**3.6196 [0.0405]**	– 0.9967 [0.3264]
Energy sector	Primary energy production	Poland	**3.1800 [0.0862]**	0.0002 [0.9896]	0.2342 [0.8166]
		Germany	1.0585 [0.4107]	**4.1260 [0.0189]**	**– 4.1868 [0.0003]**

Source: authors' own elaboration.

International economics

The topic of international economics was relatively important for both text corpora. In the Polish text collection, it was the 9th most popular theme (with an average weight of 0.0363), and in the German corpus, it was 16th (with an average weight of 0.0185). As can be seen in the word clouds associated with this theme shown in Figure 3, even though these topics were paired based on the topic matching algorithm, they seem to concern slightly different matters as the German topic is more related to cross-country comparisons and international spillovers, while the Polish topic puts more emphasis on international trade. This different focus complicates the selection of an economic indicator, which was eventually specified as trade share, defined as the sum of the nominal value of imports and exports expressed as a per cent of nominal GDP.

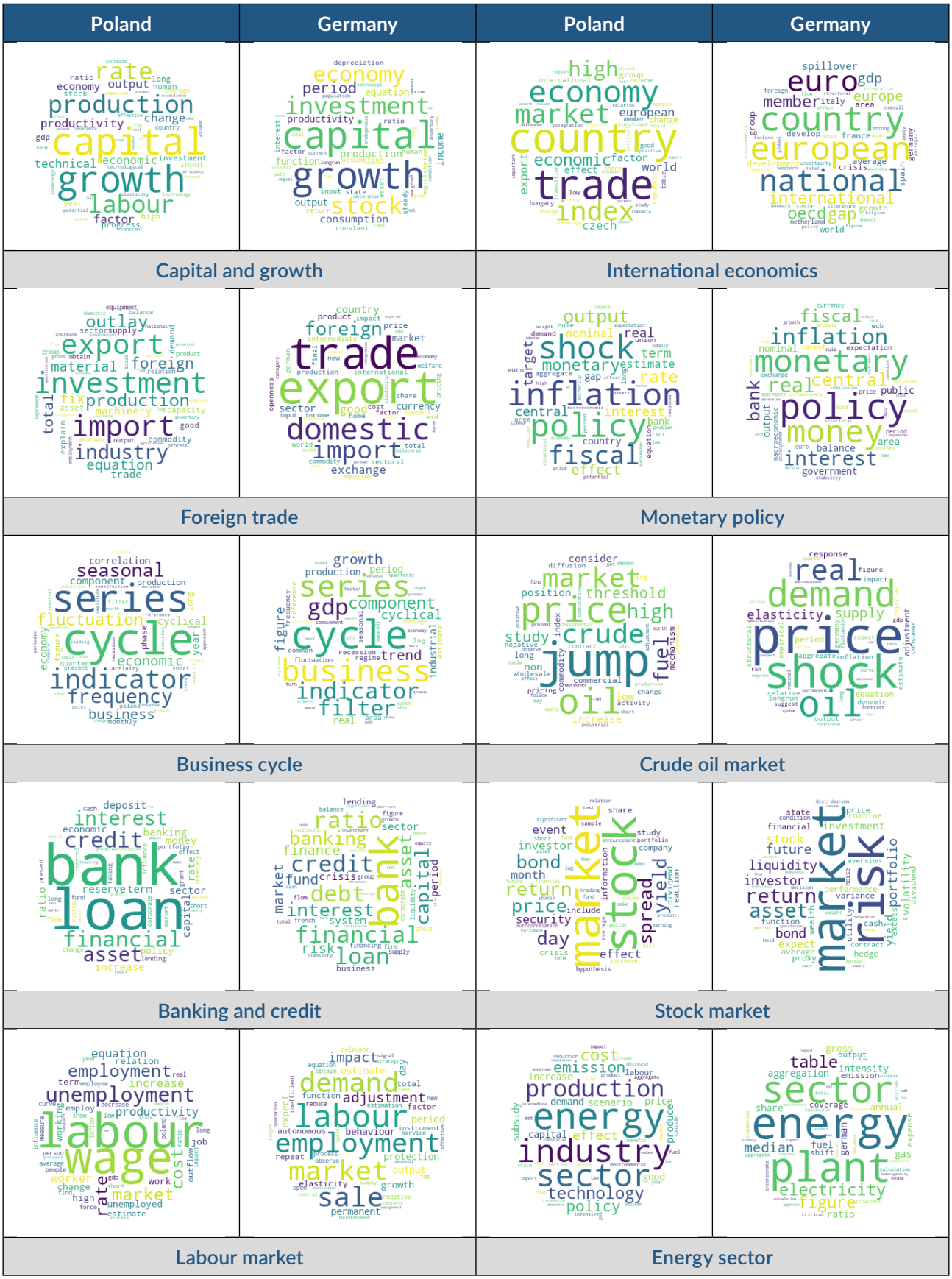

Figure 3. Word clouds

Source: authors' own elaboration.

According to the results provided in Table 2, no Granger causality between topic weights and the indicator was found for Germany, while shocks in international trade Granger caused the topic weights for Poland. For both countries, no significant instantaneous link was detected.

Foreign trade

With average weights of 0.0276 and 0.0224, the topic of foreign trade was the 15th and the 11th most discussed topic in the Polish and German text corpora, respectively. The economic indicator used in the VAR associated with foreign trade was the share of net exports in GDP. This variable was selected as the primary indicator of developments in foreign trade.

The outcomes of the Granger causality tests presented in Table 2 indicate two-way causality and instantaneous causality found for Poland and one-way causality for Germany. In the latter case, the changes in popularity of the subject in the academic literature preceded real movements in the German share of net exports in GDP.

Monetary policy

The topic labelled monetary policy was quite popular in both text corpora – it had the 16th and 13th highest mean weights in the Polish and German collections, respectively. A natural economic indicator for this topic is the monetary policy rate. Granger causality test results based on VAR that incorporated both policy rate and topic trend (see Table 2) indicate causality from the indicator to topic weights for both countries. This implies that past changes in the monetary policy rate add predictive power to the dynamic model to explain the development of topic weights over time.

Business cycle

The topic of business cycle was the 19th and 15th most popular in the Polish and German collections, respectively (the mean weights were 0.0232 and 0.0194). Bivariate VAR models were constructed for topic weights and national output gap indicators. However, no Granger causality was found for either corpus, nor was there an indication of instantaneous effects. Given the recurrence of business cycles, it might not come as a surprise that the academic literature on the topic does not lead or follow actual business cycles. Thus, the result of no Granger causality is sensible.

Crude oil market

Word clouds associated with the topic of the crude oil market (see Figure 3) show a clear focus on oil price shocks. This theme was relatively more important in the German corpus, where it was the 9th most frequently discussed topic (with an average weight of 0.0259). In the Polish text collection, it was only the 33rd most important of the 37 themes identified (with an average weight of 0.0121).

Given the word clouds, it is intuitive that the corresponding topic weights might be related to shocks in the global crude oil market rather than to an oil price series. Therefore, for this specific topic, the relevant economic indicator is not directly observable, but must be derived in a first step. To construct a series of shocks, we used the method described by Kilian (2009). It is based on a trivariate structural VAR, including log differences of world crude oil production ($\Delta prod$), an index of global real economic activity (*rea*), and the real price of oil (*rpo*) (see Table 4 for the description of the data). As recommended by Kilian (2009), the model is estimated using monthly data. The model has the following form:

$$A_0 y_t = \nu + \sum_{i=1}^{24} A_i y_{t-i} + u_t,\ A_0^{-1} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix},$$

where $y_t = (\Delta prod_t, rea_t, rpo_t)'$. The three structural shocks that Kilian (2009) labelled oil supply shocks, aggregate demand shocks, and oil-specific demand shocks are given by

$$e_t = A_0^{-1} \begin{bmatrix} u_t^{oil\ supply\ shock} \\ u_t^{aggregate\ demand\ shock} \\ u_t^{oil\ specific-demand\ shock} \end{bmatrix},$$

and represent innovations in global oil production, global demand for industrial commodities, and precautionary demand for oil, respectively.

These estimated series of structural shocks are aggregated to annual frequency as used in the present study. Unlike in other VAR models, where topic weights from the German and Polish text collections were modelled jointly with economic indicators from Germany and from Poland, respectively, in the models used to study the topic of the crude oil market, the same series of global shocks are used for both countries.

As shown in Table 2, for Poland, oil-specific demand shocks were found to be a Granger cause for the topic weights, and instantaneous causality was found for oil supply

shocks. This implies that future academic discussion on the role of the crude oil market is stimulated by demand shocks, while supply shocks might be discussed faster or – given the lag between academic research and publications – even with some lead. For Germany, we expected a similar finding in particular due to the high interest in economic science devoted to the crude oil market after the supply shocks in the 1970s and early 1980s. However, since our sample starts in 1984, these events are not part of the sample period. This might explain why no Granger causality was found for German data for the models that incorporate oil supply shocks and oil-specific demand shocks. In contrast, a surge in interest in the topic between 2002 and 2005 correlates with large shocks to the index of global demand for industrial commodities (the Kilian index, see Kilian 2009). Shocks to the global demand for industrial commodities can be transmitted (with a delay) to crude oil prices and eventually to the discussion of oil prices in the JES, which might explain the finding that aggregate demand shocks were found to be a Granger cause for crude oil market topic weights.

Banking and credit

The topic of banking and credit was the 23rd most covered theme in the Polish corpus. In the German collection, it ranked 19th. In the Granger causality analysis, topic weights were contrasted with an economic indicator for the importance of the banking sector given by the credit-to-GDP ratio. This variable proved to be Granger causal for topic weights for the German corpus, i.e., a shock to the credit-to-GDP ratio preceded changes in the importance of the topic in the academic literature. However, no Granger causality was found for the Polish text collection, nor was there an indication of contemporaneous effects.

Stock market

The topic related to the stock market attracted more attention in the German corpus, where it came 12th with an average weight of 0.0205. In the Polish text collection, it was 29th and had a mean weight of 0.0156. This discrepancy in the relative interest was expected as the Warsaw Stock Exchange did not operate during the first part of our sample period (it became active in 1991; our sample comprises data from 1995 to 2020 for Poland).

For this topic, two economic indicators were considered alternatively, as it was difficult to select the best-suited one a priori. The two indicators were the stock market return, computed as the growth rate of the annual average national stock market index, and stock price volatility, calculated as the average of the 360-day volatility of the national stock market index. The two indices considered were Deutscher Aktienindex

(DAX) and Warszawski Indeks Giełdowy (WIG), for German and Polish corpora, respectively.

The results from Table 2 indicate two-way Granger causality between stock price volatility and the topic weights for the Polish corpus. For the German text collection, topic weights were a Granger cause for the stock market returns series.

Labour market

The most important words for the labour market (see Figure 3) suggest that the topic in the German corpus has a broad focus on the labour market and its functioning. In contrast, the Polish corpus focuses more on wage and (un-)employment. The weights of this topic were 0.0198 and 0.0092 for the Polish and German corpora, respectively. For both text collections, the topic belonged to the bottom half of the most popular themes (22nd place out of 37 for Poland and 39th out of 60 for Germany). Topic weights were modelled jointly with the unemployment rate. The outcomes of Granger causality tests were as follows: causality from indicator to topic weights was found for the German corpus, and instantaneous causality was detected for the Polish corpus.

Energy sector

The energy sector was not a very popular topic in either corpus. With an average weight of 0.0159, it was 28th on the list of most frequently discussed topics for Poland. For the German corpus, it was the third least important theme (with a mean weight of only 0.0053, it occupied 57th place). The economic indicator selected for causality analysis was primary energy production.

The results from Table 2 show significant links between topic weights and the economic indicator for both corpora. The direction of causality is, however, different: for the German corpus, real developments precede and are simultaneous with the changes in topic weights, while there is causality from topic weights to the real indicator in the case of the Polish corpus.

Conclusions

We used text mining techniques to identify topics discussed in two academic text corpora on economics from Germany and Poland for the same period, 1984–2020. Our main focus was on the relative importance of these topics over time and how they corresponded to central economic indicators related to the topics. For one theme, which corresponded to shocks to the crude oil market, the indicator had to be derived from an auxiliary model.

In order to determine whether economic research led or followed real events, bivariate relationships between topic trends and economic variables were analysed using vector autoregressive models and Granger and instantaneous causality tests. We considered ten distinct topics which appeared in both text corpora. This allowed us to study whether Granger causality between topic trends and the corresponding indicators was frequent and also which direction of causality prevailed. Furthermore, parallel analysis for German and Polish textual data and economic indicators made it possible to compare results for these two countries.

The analysis indicated significant links between academic literature and real developments for at least one country for all but one pair of topic and the corresponding economic indicator. This exception was given by the topic of business cycle and the output gap. In this case, academic analysis might be focused more on the existence and stability of the recurring cycles than on each particular cycle, which might explain the lack of a significant link.

In general, the reason for not detecting causality between topics and indicators might also be due to the relatively small sample size, the imperfect matching of topics from the German and Polish corpora and, consequently, problems with selecting an appropriate economic indicator that fits the topics for both countries. Therefore, the substantial number of significant links actually found indicates a strong focus of researchers publishing in the two corpora on empirical evidence. However, the results of the direction of Granger causality were mixed. Examples of instantaneous causality, both kinds of unidirectional causality, and two-way causality were found. Overall, it can be concluded that economic indicators led topic trends more often than the other way round. Thus, economists tend to follow real developments in their analysis rather than predict them.

While the frequency of significant links between economic variables and topic popularity for the Polish and German corpora were comparable, causality patterns for specific topic-indicator pairs were often not the same. Similarities included, for example, significant reactions by researchers of the topic of monetary policy to changes in the policy rate and Granger causality from the growth rate of gross fixed capital formation to the trend of the topic capital and growth. Interestingly, the discussion in economic science of foreign trade preceded changes in the share of net exports in GDP in both countries, i.e., globalisation was discussed by researchers prior to its realisation. Some differences in the results across countries, e.g., for the topics on the stock market or the energy sector, can be explained by the different economic settings in Poland and Germany during the years under investigation. For example, the stock exchange only emerged in Poland during the sample period, and energy production mixes were not comparable, which might be reflected in the focus and content of economic discussion of these topics.

There are several limitations of our analysis, which might be considered a first explorative study of the link between economic science and economic reality in a cross country comparison. Further research should address both methodological and content-related issues. On the methodological side, alternative methods for identifying (common) topics and quantifying their relevance over time might be considered. As far as content is concerned, it might be of interest to include text corpora from other countries and to extend the observation period. Further research should also focus on the link between topics and economic reality for specific topics, possibly using case studies for a better understanding of the driving forces behind the links found in our analysis.

Acknowledgements

Financial support from the German Research Foundation (DFG) (WI 2024/8–1) and the National Science Centre (NCN) (Beethoven Classic 3: UMO–2018/31/G/HS4/00869) for the project TEXTMOD is gratefully acknowledged. The project also benefited from cooperation within HiTEC Cost Action CA 21163.

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Porównanie zależności pomiędzy popularnością tematów artykułów naukowych i zmiennymi ekonomicznymi dla Polski i Niemiec

W ostatnim czasie obserwować można gwałtowny wzrost popularności metod analizy ekonomicznej wykorzystującej zmienne pozyskane z tekstów. Jednym z najczęściej stosowanych podejść jest modelowanie tematów, które pozwala na oszacowanie, jak waga poszczególnych tematów zmieniała się w czasie. Celem artykułu jest zbadanie, czy mierzona za pomocą wag popularność tematów była powiązana z wybranymi zmiennymi ekonomicznymi. W badaniu wykorzystano artykuły naukowe z obszaru ekonomii, opublikowane w Polsce i Niemczech w latach 1984–2020. Jednym z celów analizy było stwierdzenie, czy zależności pomiędzy popularnością wybranych tematów w Polsce i w Niemczech i powiązanymi z nimi wskaźnikami ekonomicznymi były podobne. Badanie przeprowadzono za pomocą modeli wektorowej autoregresji i testów przyczynowości Grangera.

Słowa kluczowe: modelowanie tematów, analiza tekstu, alokacja zmiennej ukrytej Dirichleta, przyczynowość w sensie Grangera, popularność tematów

Appendix

A. Data sources

A1. Selection of topics for further analysis

after the analysis of the topic word clouds, 10 out of 24 topics were selected for the analysis (see Table 1). Nine topics, labelled forecasting, time series econometrics, econometric models, estimation methods, economic theories, input-output analysis, simulation methods, allocation optimisation and welfare economics were identified as methodological or theoretical and thus disregarded from this study. Four further topics, corresponding to firm growth, market competition, household income, and employment and wage were also rejected as they seemed to correspond to the micro economic level, which might not be well reflected in the aggregated observed time series employed in this paper. Finally, the topic labelled East-West German studies was disregarded as it deals with studying the consequences of a specific event.

A2. Data sources and data transformations

Table 3. Description of data

Topic	Variable	Poland		Germany	
		Source	Span	Source	Span
Capital and growth	Investment growth rate	OECD.Stat	1991–2020	OECD.Stat	1984–2020
International economics	Trade-to-GDP ratio	OECD.Stat	1990–2020	OECD.Stat	1990–2020
Foreign trade	Net Export-to-GDP ratio	OECD.Stat	1990–2020	OECD.Stat	1984–2020
Monetary policy	Central bank discount rate	National Bank of Poland	1989–2020	Bundesbank	1984–2020
Business cycle	Output gap (HP filter)	OECD.Stat	1990–2020	OECD.Stat	1984–2020
Banking and credit	Credit-to-GDP ratio (actual)	BIS	1992–2020	BIS	1984–2020
Stock market (returns)	Growth rate of annual average stock market index	World Bank	1995–2020	World Bank	1989–2020
Stock market (volatility)	Average of the 360-day volatility of the national stock market index	World Bank	1995–2020	World Bank	1988–2020
Labour market	Unemployment rate	Statistics Poland	1990–2020	OECD.Stat	1984–2020
Energy sector	Primary energy production	Eurostat	1990–2020	Eurostat	1990–2020

Source: authors' own elaboration.

Table 4. Data for the model of oil shocks

Variable	Source	Span
Index of global real economic activity	Federal Reserve Bank of Dallas	1984–2020
Global crude oil production	U.S. Energy Information Administration (EIA)	1984–2020
U.S. crude oil imported acquisition cost by refiners (dollars per barrel)	U.S. Energy Information Administration (EIA)	1984–2020
U.S. CPI (all items) seasonally adjusted	OECD	1984–2020

Source: authors' own elaboration.

Table 5. Data transformations

Topic	Poland		Germany	
	Topic weight transformation	Economic indicator transformation	Topic weight transformation	Economic indicator transformation
Capital and growth	None	None	None	None
International economics	None	First difference	None	First difference
Foreign trade	None	First difference	None	First difference
Monetary policy	None	None	None	None
Business cycle	None	None	None	None
Crude oil market (oil supply shock)	None	None	None	None
Crude oil market (aggregate demand shock)	None	None	None	None
Crude oil market (oil specific-demand shock)	None	None	None	None
Banking and credit	None	First difference	None	First difference
Stock market (returns)	None	None	None	None
Stock market (volatility)	None	None	None	None
Labour market	None	First difference	None	First difference
Energy sector	None	First difference of logs	None	First difference of logs

Source: authors' own elaboration.

Table 6. Model details

Topic	Poland			Germany		
	VAR lag order	Deterministic terms	Standard errors	VAR lag order	Deterministic terms	Standard errors
Capital and growth	4	None	OLS	2	t	HAC
International economics	1	t, t^2	OLS	1	t, t^2	OLS
Foreign trade	3	t^2	HAC	4	t, t^2	HAC
Monetary policy	1	t, t^2	HAC	1	none	HAC
Business cycle	1	t, t^2	HAC	3	t, t^2	HAC
Crude oil market (oil supply shock)	1	t, t^2	HAC	1	none	OLS
Crude oil market (aggregate demand shock)	1	t, t^2	HAC	1	none	HAC
Crude oil market (oil specific-demand shock)	1	t, t^2	OLS	1	none	HAC
Banking and credit	1	none	OLS	1	none	OLS
Stock market (returns)	1	none	HAC	1	none	HAC
Stock market (volatility)	4	t, t^2	HAC	1	none	OLS
Labour market	1	none	OLS	2	t, t^2	OLS
Energy sector	1	none	HAC	4	t, t^2	HAC

Source: authors' own elaboration.

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.11

Relationships between Inflation and Unemployment in the United States, Japan and Germany during the Economic Crisis Caused by the COVID–19 Pandemic

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Abstract

The aim of the article is to clarify the controversies surrounding the relationship between inflation and unemployment in the three most economically significant countries in the world (apart from China), namely the United States, Japan, and Germany, during the coronavirus pandemic (from January 2020 to February 2022). The pandemic has had various adverse effects worldwide, including a severe economic crisis lasting from the first quarter of 2020 to the end of the first quarter of 2021. The primary causes of this crisis include declines in aggregate supply due to lockdowns in many sectors of the economy, particularly the service sector. A decrease in aggregate supply should cause not only an increase in unemployment but also an increase in inflation. The article, therefore, hypothesises that the relationships between unemployment and inflation in the countries studied during the above period were unidirectional. To verify this hypothesis, two basic research methods were used: analysis of correlation coefficients between the variables mentioned above and the shape of Phillips curves. Ultimately, the hypothesis was rejected because inflation during this period showed a decreasing tendency (mainly due to a significant drop in commodity prices). The article extends research presented in the literature before 2020, offering additional value by examining the period of the pandemic which precipitated an economic crisis. Future analysis should be expanded to include more variables (including the output gap) in line with the New Keynesian Phillips Curve.

Received: 12.06.2023. Verified: 18.10.2023. Accepted: 2.04.2024

Keywords: unemployment, inflation, Phillips curve, economic crisis, pandemic

JEL: E24, E31, E32, I1

Introduction

The complexity of mechanisms that govern the economy makes fundamental macroeconomic categories, such as inflation and unemployment, interdependent. There are conflicting economic goals since the aggregate demand that stimulates policy, and that is aimed at reducing unemployment may cause increased inflation. In turn, if the aggregate demand-suppressing policy is carried out to curb inflation, it may result in increased unemployment. The article aims to explain controversies surrounding the relationships between the above-mentioned variables in the three economically most important countries in the world, excluding China, i.e. the United States, Japan and Germany, during the economic crisis caused by the COVID–19 pandemic (from January 2020 to March 2021[1]).

The study consists of this introduction, two main parts and a summary. The first main part describes relationships between inflation and unemployment based on theories and research connected primarily with different types of the Phillips curve. The second part presents a statistical illustration of inflation and unemployment rates, as well as correlation coefficients between the variables and shapes of Phillips curves in the studied countries from the 1st quarter of 2020 to the 1st quarter of 2021. On this basis, we attempt to verify the hypothesis that Phillips curves were positively sloped (meaning that increased unemployment would be accompanied by increased inflation) in the period due to supply restrictions caused by lockdowns. The deliberations are recapitulated in a summary containing final conclusions.

Relationships between inflation and unemployment in the light of different versions of the Phillips curve

The first person to analyse the relationships between inflation and unemployment was Irving Fisher, the renowned economist, who observed a negative correlation between the two variables (as early as the 1920s). More specifically, he found a positive correlation between the rate of American dollar value changes and unemployment. According to Fisher, business owners view inflation positively as their revenues increase proportionally to the rising prices. Meanwhile, their expenditures grow more slowly

1 Although the COVID–19 pandemic continued beyond this date, it is conventionally accepted that the economic crisis finished in the 1st quarter of 2021, which will be discussed further in the article as well.

because they are based on more long-term contracts. Consequently, profits rise during inflation, thus stimulating employment, which reduces unemployment (Fisher 1926, pp. 786–788).

In terms of economic theory, the Phillips curve is the most widely recognised concept to explain the relationships between inflation and unemployment. It takes its name from New Zealand economist A.W. Phillips, who explored relationships between nominal wage changes and unemployment rather than those between changing prices and unemployment. His analysis concerned Great Britain from 1861 to 1957. Assuming that the nominal wage growth rate may be regarded as a type of inflation (wage inflation), conclusions similar to those reached by Fisher can be drawn. The observed negative relationship between the analysed values may be explained as follows: When unemployment is low, employees can be expected to demand fast wage rises while employers will strive to accommodate those demands. What is more, every firm will try to offer above-average wages to attract the best-qualified labour force. On the other hand, when unemployment is high, employees will have a weaker bargaining position in the labour market, hence the wage increase rate will be low (Phillips 1958, p. 283). In Phillips's opinion, however, the relationship between wage increases and unemployment is non-linear because employees are very unwilling to accept wage reductions even in times of falling employment, which means that Phillips accepts Keynesian downward rigidity of wages. As a result, declining unemployment is accompanied by a relatively quick wage rise, while increasing unemployment is accompanied by only a slight reduction in the wage increase rate (Phillips 1969, pp. 277–278).

Lipsey played a prominent role in transforming the Phillips curve into a coherent theoretical construct. He offered a more in-depth understanding of the statistical relationship found by Phillips. He did it by positing the occurrence of: (1) A unidirectional relationship between surplus demand for the labour force and the nominal wage rise rate and (2) a multidirectional relationship between that surplus and the unemployment rate (Belka 1986, pp. 202–203; Snowdon, Vane, and Wynarczyk 1998, pp. 159–160). Later on, the modified Phillips curve, which illustrates relationships between the unemployment rate and the conventional inflation rate, indicating the general price increase rate, became more popular. Friedman and Phelps, among others, analysed associations between the variables.

Friedman's deliberations show that he partly accepted Fisher's view on the negative relationship between inflation and unemployment. Thus, applying expansionary fiscal and/or monetary policy may bring about desired effects in the form of reduced unemployment. However, this is primarily achievable in the short run, when the increased money supply and income have a more substantial impact on output and employment growth than on increased prices (following the Keynesian assumption of unused production capacity in the economy).

Nevertheless, this effectiveness is mainly due to the fact that enterprises and their employees have been "misled" into treating changes in nominal values as if they were real. That may be the case when they make their economic decisions according to the adaptive expectations hypothesis. Thus, after a period of stable prices, workers may interpret nominal wage rises as real, which increases the cost-effectiveness of work and the supply of the labour force. Therefore, unemployment would fall below its natural rate (Friedman 1977).

Phelps also drew attention to a possible substitution between unemployment and inflation. His analyses showed that inflation depends on, among other things, the degree of production capacity use. Only when the economy manufactures at full capacity will the real inflation rate equal the expected inflation rate. If the national income produced exceeds the potential income, the current inflation rate will exceed the expected inflation rate. On the other hand, unused production capacity will lead to the opposite situation, i.e., the real inflation rate will be lower than the expected one (Phelps 1967, pp. 261–263). Considering that unemployment is also dependent on the extent of production capacity used (it is higher than natural if there is unused production capacity), Phelps' analyses showed that the relationship between the studied variables would also be reversed (i.e. higher unemployment will correspond to lower inflation).

In the 1970s, Lucas, as well as Sargent and Wallace, drew attention to a possible reverse relationship between unemployment and inflation, but solely under specific conditions. Lucas posited that positive deviations of current real wages from their "normal" increase rate and deviations of prices from their perceived "normal" trend have a positive effect on labour supply and output (Lucas Jr. and Rapping 1969, p. 747). This is because the latter factor contributes to increasing "information noise", which, in turn, makes it more difficult for economic subjects to differentiate general from relative price increases (Lucas Jr. 1973, p. 327). Both employers and employees acquire information about the prices of goods they produce or increases in wages offered to them faster than information about general price rises. Employers may misinterpret inflation as an increase in the relative price of a good offered for sale. Consequently, business owners may increase supply, leading to a rise in aggregate output beyond its potential volume. This scenario becomes plausible, especially when employees in the discussed model of misperceptions also increase labour supply, initially considering wage rises to be real. However, such a situation may occur only until economic subjects remain "misled", thinking that rises in prices of offered goods and wages exceed inflation (Lucas Jr. 1973, p. 333).

In turn, Sargent and Wallace's concept shows that a price rise may be accompanied by real national income growth and unemployment reduction. However, this will happen only in the event of an unexpected monetary "surprise" in the form of a higher-than-expected money supply increase rate. Although a growth in money supply will be "embedded"

in economic entities' predictions, assuming their rational expectations, decision-makers may increase the money supply by a greater percent than in previous periods (Sargent and Wallace 1975, p. 243). That additional, unexpected expansion will then contribute not only to a price rise but also to increased output and employment (Snowdon, Vane, and Wynarczyk 1998, p. 212).

In more contemporary analyses, possible negative relationships between inflation and unemployment are typically explained by the "grease" effect, i.e., inflation rises have positive effects on the labour market in low inflation conditions. It may be connected with the optimistic moods of business owners. The principal factor that makes the grease effect work is the downward rigidity of nominal wages, which allows real prices to decrease only when inflation co-occurs with the money illusion of employees (Groshen and Schweizer 1997, pp. 1–4). A real wage fall that contributes to decreased production costs may then result in increased output and employment.

Prices are procyclical in all the above-mentioned models. As unemployment is a countercyclical variable, relationships between unemployment and inflation are multidirectional. While they move along the Phillips curve, decision-makers may choose a combination of unemployment and inflation, which will involve the lowest costs of those phenomena from the social and economic point of view (Niskanen 2002, p. 193). However, the choice of an optimum combination is always painful, i.e., lower unemployment at the cost of higher inflation or lower inflation at the expense of higher unemployment (Belka 1986, pp. 204–205). Thus, it largely depends on the priorities set by decision-makers.

The possible substitution between the two values resulting from the modified Phillips curve has been proven by economic reality. Therefore, in the 1960s and early 1970s, the negatively sloped Phillips curve gained immense popularity, becoming the basis of many countries' economic policies. In the 1970s, however, a then-surprising phenomenon of stagflation occurred (Niskanen 2002, p. 194). Consequently, the notion that the negatively sloped Phillips curve may accurately explain the described processes only in the short run, and even that this is dependent on economic entities' incorrect predictions about inflation, started to play an increasingly important role (as asserted by Friedman, Lucas, Sargent and Wallace). Subsequently, the long-run vertical Phillips curve appeared in the economic discourse, indicating a lack of relationship between unemployment and inflation. Phillips himself claimed that the trade-off between the wage increase rate and the unemployment rate would not apply to periods characterised by quickly rising prices of imported goods (Phillips 1969, pp. 296–297).

A little later, Samuelson and Solow (1960, p. 190) drew attention to the occurrence of cost-push inflation while also noting that unemployment may be structural. That type of unemployment is not dependent on economic fluctuations; hence, no substitution would occur between unemployment and inflation either.

In turn, as already mentioned, according to Friedman, unemployment and inflation substitution are possible. However, it may principally appear in the short run when economic entities operate in accordance with the adaptive expectations hypothesis. However, increased money supply and, consequently, increased total demand result in price rises after some time. At a certain point, the rises start to be considered in calculations by employees who will ultimately realise that their real wages have not increased despite nominal wage rises. As a result, some employees will give up their jobs, reducing the labour supply. Thus, unemployment will return to its natural rate (Friedman 1968, pp. 8–12). A similar course of events can also be observed in models by Lucas, as well as Sargent and Wallace. The occurrence of both "information noise" and "money surprise" is doubtful (or at least rare) in the economic reality.

Neo-Keynesian models of the Phillips curve also point to somewhat weak relationships between inflation, economic fluctuations and unemployment, highlighting the fact that prices do not often change, hence their limited relationship with phases of the economic cycle. For example, the near-rational model by Akerlof, Dickens, and Perry posited that low inflation is commonly ignored by enterprises, which do not consider that in setting the prices of produced goods. Their behaviour is similar with respect to wages since costs of frequent price and wage changes at low inflation could exceed the corresponding revenues. Therefore, wages and prices in enterprises fall in real terms (Akerlof, Dickens, and Perry 2000, pp. 20–23, 42–44).

Due to rigidities assumed in neo-Keynesian models, the models typically accept that firms determine the prices of goods they produce for relatively sustained periods. Along with deferred price-change decisions, the models often posit that price changes do not occur in response to any kind of changes in demand or costs, but only upon crossing a certain threshold (Roberts 1995, p. 976). Thus, relationships between prices and unemployment are also slightly rigid.

Although the negatively sloped and vertical Phillips curves had their rightful place in the history of economics, the Phillips curve may also be positively sloped in economic reality. This arises from the very definition of stagflation, as the term denotes a simultaneous rise in both unemployment and inflation (Niskanen 2002, p. 194). Hence, relationships between unemployment and inflation would be unidirectional, and the Phillips curve would be positively sloped. That may be the case when cost-push rather than demand-pull inflation occurs, as pointed out by Samuelson and Solow as far back as 1960. In such a case, an increase in costs may contribute not only to a rise in prices but also to a fall in employment in enterprises (Samuelson and Solow 1960, pp. 180–182). A rise in costs may also lead to a fall in aggregate supply. That, in turn, contributes to an even faster rise in prices, *ceteris paribus*.

On the other hand, a growth in aggregate supply, *ceteris paribus*, would cause an increase in output and employment and a decrease in unemployment and inflation.

In that context, the state may influence not only the demand side but also the supply side of the economy in the long run. Growth in aggregate supply may be affected by increasing production capacity as a result of increasing the volume of economic resources and technological progress. That can be achieved in the long run thanks to spending more on education and research and development (R&D), as well as by introducing more stable tax laws that offer tax reliefs for new business owners and a pro-family policy that increases the future volume of the labour force. Low unemployment could then be accompanied by low inflation. This situation would be possible if enterprises curbed wage rises while simultaneously increasing productivity. Thus, they would be able to boost employment without raising prices (Levy 2001, p. 282).

On the other hand, bad macroeconomic policy, manifested in the long run by, among others, a failure to promote R&D or unstable and complicated laws with high taxes, could decrease aggregate supply. Consequently, both unemployment and inflation would probably rise, even if the central bank increased money supply.

In more contemporary analyses, representatives of the real business cycle school referred to the concept of cost-push inflation and changes in prices due to changes in aggregate supply. In their opinion, the price level is mainly connected with the supply side of the economy. Therefore, it principally depends on production capacity and supply shocks rather than on aggregate demand. According to that approach, prices are anticyclical, and inflation results from a negative supply shock. The negative shock may be caused by different factors, which may include adverse weather conditions, wars, political coups and social unrest, significant rises in raw material prices, and natural catastrophes (Snowdon, Vane, and Wynarczyk 1998, pp. 256–277). Until 2020, the last category had seemed to primarily include earthquakes, droughts and floods. However, the COVID–19 pandemic may undoubtedly be considered a kind of natural catastrophe. It caused a negative supply shock since lockdowns led to the closure of many enterprises (mainly in the service sector) for some time. That might suggest that prices should be anticyclical during an economic crisis caused by a pandemic.

Apart from isolated theories, the price level is typically determined by both demand and supply factors in economic reality. Either may prevail in various periods. Moreover, in certain cases, categorising inflation as demand-pull or cost-push may solely depend on what period is chosen as a base for analysis. The inflation process entails a series of dynamic interactions in which consecutive impulses result in subsequent impulses leading to new ones and so forth (Żukowski 1997, pp. 216–217).

During an economic crisis, when both supply and demand fall, the net effect on inflation is uncertain. It depends on which of the falls is more significant: If demand decreases more than supply (inflation or even the price level will fall) or vice versa (inflation will rise). If automatic stabilisers act during a crisis, aggregate demand usually declines more slowly than aggregate supply. Thus, prices should ultimately rise, although to a lesser extent than in an economic boom. However, if aggregate supply is considered

likely to fall significantly, as it did during the COVID–19 pandemic, due to freezing a large part of the economy unconnected with the lack of demand, inflation, or at least the price level, should continue to rise, as inflation is anticyclical. This effect was intensified by increases in aggregate demand in periods between pandemic waves when the unfreezing of economies took place. On the other hand, unemployment is traditionally considered an anticyclical variable, hence it should be expected to rise during an economic crisis. Taking the above analysis into account, in the next section, we verify the hypothesis that Phillips curves were positively sloped due to supply restrictions caused by lockdowns.

Relationships between inflation and unemployment during the economic crisis caused by the COVID–19 pandemic

The COVID–19 pandemic caused a series of adverse consequences in the world, including a grave economic crisis. The analysis of relationships between unemployment and inflation during the crisis concerns three of the four largest economies in the world in terms of their produced nominal GDP, i.e. the United States, Japan and Germany (see Table 1). They are among the group of developed countries, also in terms of GDP per capita. Despite being one of the most economically important countries in the world, China was excluded from the study since it had a different economic system than the other countries for most of the period. Moreover, it had lower GDP per capita.

Table 1. The economically most important countries in the world in terms of nominal GDP in 2021 (in USD trillions)

Position	Country	GDP (in bn USD)
1	**United States**	**22.998**
2	China	17.458
3	**Japan**	**4.937**
4	**Germany**	**4.226**
5	Great Britain	3.188
6	India	3.042
7	France	2.936
8	Italy	2.101
9	Canada	1.991
10	South Korea	1.799

Note: The countries analysed in the article are in bold.
Source: International Monetary Fund (2022).

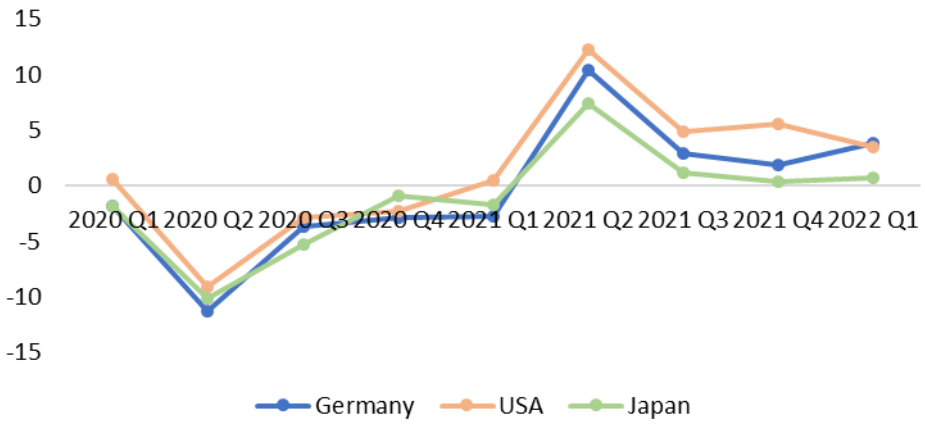

Figure 1. The real GDP growth rate (in per cent) in the United States, Japan and Germany from the 1st quarter of 2020 to the 1st quarter of 2022 (compared to the corresponding quarter of the preceding year)

Source: own work based on Organization for Economic Co-operation and Development (2022).

The data presented in Figure 1 indicates significant business cycle synchronisation in all three analysed countries. The economic crisis caused by the COVID–19 pandemic lasted from the 1st quarter of 2020 to the 1st quarter of 2021. However, a powerful rebound occurred as early as the 2nd quarter of 2021, which was partly due to real factors connected with the temporary easing of restrictions and partly to a low base effect.

In order to present relationships between unemployment and inflation during the economic crisis (the 1st quarter of 2020 – the 1st quarter of 2021), linear correlation coefficients were computed between the variables. The calculations were also made considering lags of one variable relative to the other of 1, 2 and 3 months, respectively. The results are presented in Table 2, which shows that the coefficients were negative in the vast majority of cases for all three countries (except for three-month inflation lags in the United States and Germany, and three-month unemployment lags in the United States). Except for Japan, the coefficient values markedly decreased with increasing lags as a rule. Nevertheless, if lags are not considered, the coefficients may be considered to be surprisingly high: about –0.53 in Germany, about –0.64 in Japan (where an even higher value – about –0.78 – may be observed with three-month inflation lags) and about –0.87 in the United States. Therefore, the hypothesis about positive relationships between unemployment and inflation during the economic crisis caused by the pandemic should be categorically rejected for all three countries, in particular, the US and, to a slightly lesser extent, Japan and Germany.

Table 2. Unemployment rate (u) – inflation rate (i) correlation coefficients in the most economically important countries of the world from January 2020 to March 2021

Relationship	Japan	USA	Germany
$u_t - i_t$	–0.640	–0.866	–0.533
$u_t - i_{t+1}$	–0.693	–0.563	–0.382
$u_t - i_{t+2}$	–0.764	–0.028	–0.193
$u_t - i_{t+3}$	–0.778	0.271	0.016
$u_{t+1} - i_t$	–0.538	–0.729	–0.684
$u_{t+2} - i_t$	–0.332	–0.146	–0.796
$u_{t+3} - i_t$	–0.013	0.456	–0.768

Source: own calculations based on FRED Economic Data (2021); Eurostat (2024a; 2024b).

The graphical illustrations presented in Figures 2–4, which depict the relationships between unemployment and inflation in all three countries, confirm the negative slope of the Phillips curves.

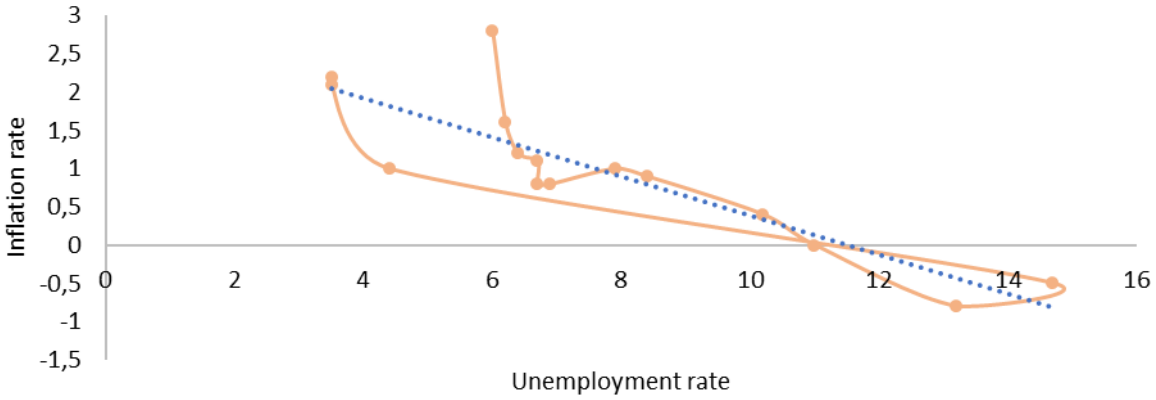

Figure 2. Relationships between inflation and unemployment rates (in per cent) in the United States from January 2020 to March 2021 (linear trend)

Source: as for Table 2.

Furthermore, it can be observed that the unemployment rates showed an upward trend in all three countries during the economic crisis caused by the pandemic (see Figure 5). There was then a fall after the 2nd quarter of 2021. In Germany and Japan, however, there was only a slight rise during the economic crisis (until the 1st quarter of 2021) and a slight fall during the economic recovery (since the 2nd quarter of 2021). Thus, unemployment was a typical anticyclical variable in those countries in the studied period, although the changes were only minor. At the end of the crisis, unemployment was roughly 4% and 3% in Germany and Japan, respectively. At the end of the 1st quarter of 2022, it was lower by about 0.5 pp in both countries. The situation was slightly different in the United States, where unemployment was extremely sensitive to the occurrence

of the COVID–19 pandemic, reaching almost 15% as early as April 2020. As mandatory restrictions were subsequently relaxed and households and firms adapted to the pandemic, many sectors of the economy recovered rapidly, and unemployment fell (Federal Reserve System 2021). Still, the rate below 5% was reached as late as September 2021.

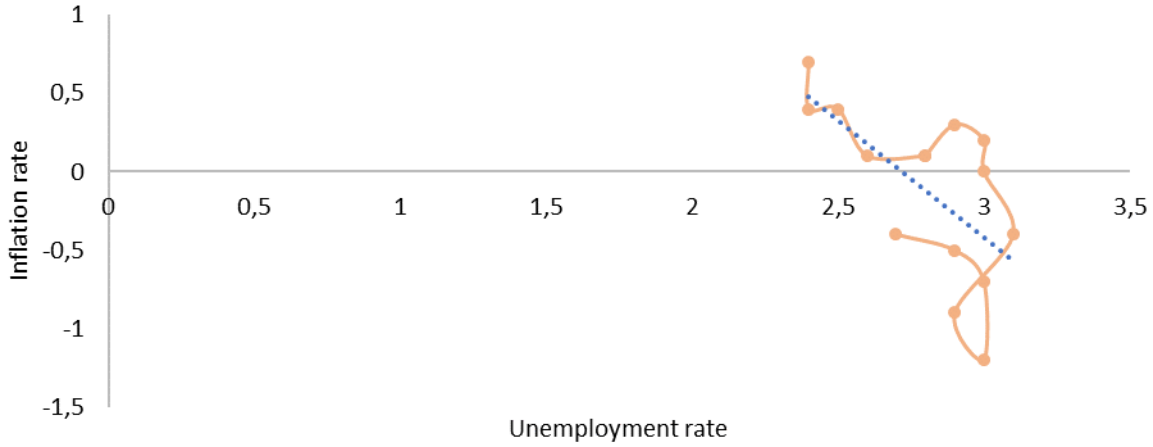

Figure 3. Relationships between inflation and unemployment rates (in per cent) in Japan from January 2020 to March 2021 (linear trend)

Source: as for Table 2.

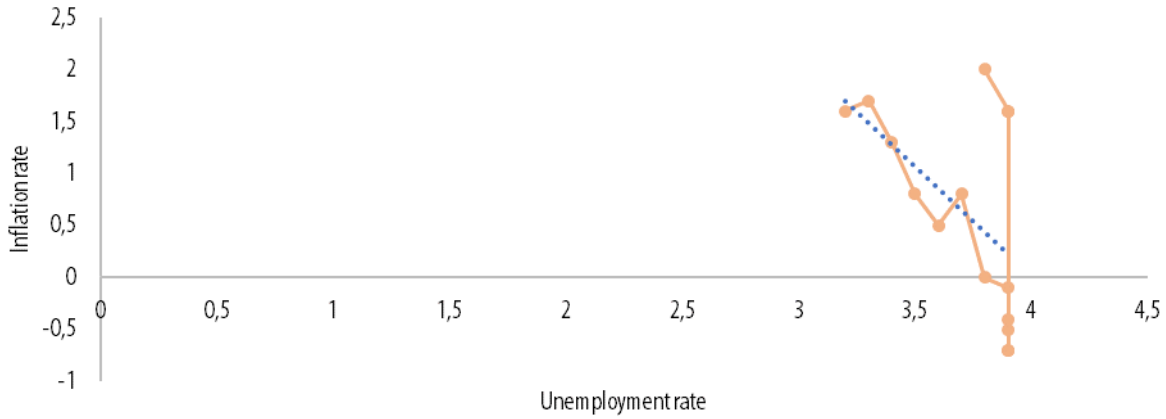

Figure 4. Relationships between inflation and unemployment rates (in per cent) in Germany from January 2020 to March 2021 (linear trend)

Source: as for Table 2.

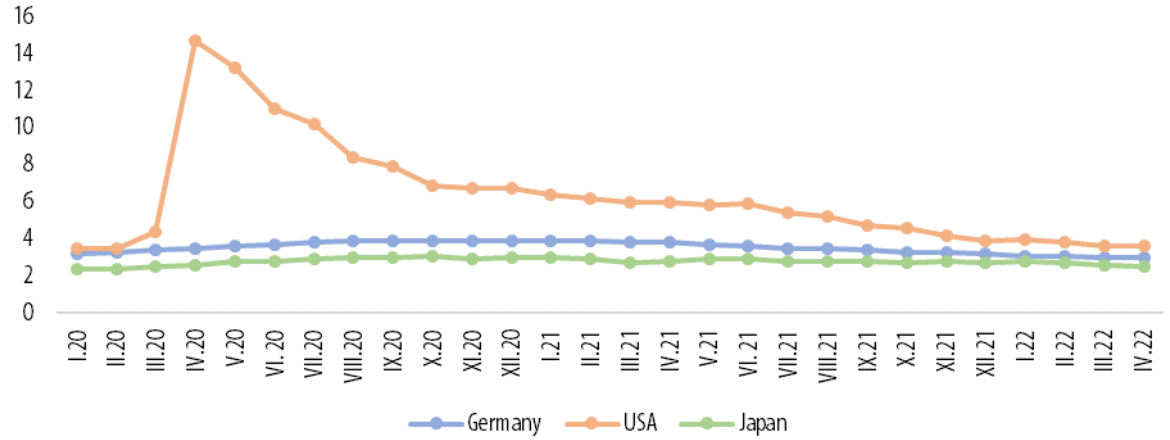

Figure 5. Unemployment rate (in per cent) in the United States, Japan and Germany from January 2020 to April 2022

Source: own work based on Eurostat (2024b).

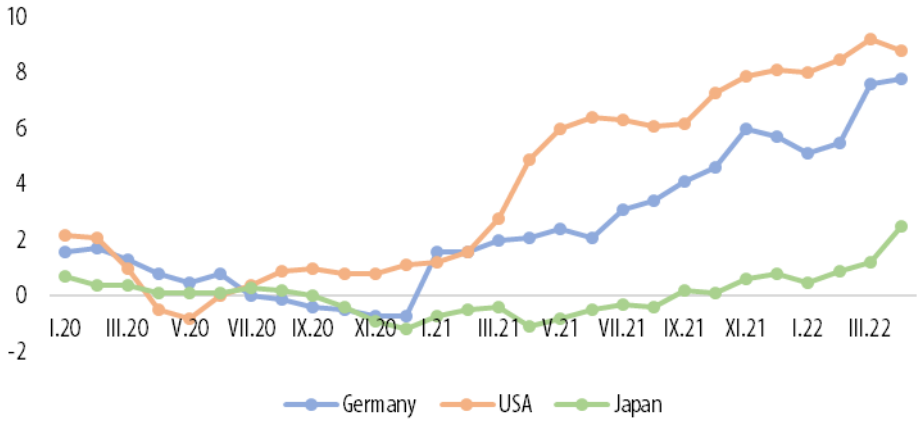

Figure 6. Inflation rate in the United States, Japan and Germany from January 2020 to April 2022

Source: own work based on FRED Economic Data (2021); Eurostat (2024c).

The data in Figure 6 show clear deflationary processes in 2020 (in the United States until May and in Germany and Japan until December). The fall in global inflation in the first months of the pandemic was due to a negative demand gap connected with a decline in aggregate demand and a general weakening of economic activity. This, in turn, was connected with a limited supply of goods and services in some branches of the economy (due to the lockdown) and the loss of income among owners who operated in those branches. Moreover, inflation also fell at that time as a result of a significant decrease in food, raw material and oil prices (roughly until September 2020). Thus, an upward trend in unemployment co-occurred with a downward trend in inflation for most of the economic crisis caused by the pandemic. The latter, to a large extent, resulted from extraordinary circumstances connected with a considerable fall in raw material prices (Bank of Japan 2020; European Central Bank 2020; Federal Reserve System 2020; 2021).

The most direct effect of the pandemic was a significant fall in aggregate supply (due to the closure of many economic branches), which necessarily led to increasing inflation in 2021 (see Figure 6). Other factors that pushed up inflation at that time may include an increase in aggregate demand in restriction easing periods (satisfying deferred demand) and an increase in operation costs on the part of enterprises. The latter was mainly associated with a significantly intensified "rebound" of energy and raw material prices (Bank of Japan 2022; European Central Bank 2022; Federal Reserve System 2022). For instance, the average price of oil worldwide in November 2021 was 80% higher than the year before, while coal was more than two and a half times more expensive and natural gas more than five times as expensive (National Bank of Poland 2021). Further increases took place in the first months of 2022. Again, they mostly concerned natural gas, which became more than twice as expensive between January and March. This was due to the Russian aggression against Ukraine, which led to a limited supply in most European countries. Agricultural raw materials also increased in price due to the limited supply from Ukraine (National Bank of Poland 2022).

Table 3. Unemployment rate (u) – inflation rate (i) correlation coefficients in the most economically important countries of the world from January 2020 to April 2022

Relationship	Japan	USA	Germany
$u_t - i_t$	–0.575	–0.689	–0.815
$u_t - i_{t+1}$	–0.493	–0.638	–0.773
$u_t - i_{t+2}$	–0.464	–0.541	–0.676
$u_t - i_{t+3}$	–0.404	–0.483	–0.550
$u_{t+1} - i_t$	–0.617	–0.711	–0.902
$u_{t+2} - i_t$	–0.443	–0.672	–0.951
$u_{t+3} - i_t$	–0.218	–0.618	–0.956

Source: as for Table 2.

It stems from the above analysis that a reversal of the situation was observed in the world economy in 2021 as the end of the crisis made the labour market situation improve and unemployment fall. In turn, inflation showed a strong upward trend. Thus, relationships between the variables remained multidirectional (negative). Therefore, extending the study period by subsequent months, in which the COVID–19 pandemic was still present but the economic crisis was already over, would not change the above conclusions, resulting in the rejection of the hypothesis. What is more, Table 3 shows that correlations between the variables would be even stronger in some variants. This refers mainly to Germany, where, with 2- and 3-month unemployment lags, negative coefficients exceeded –0.95.

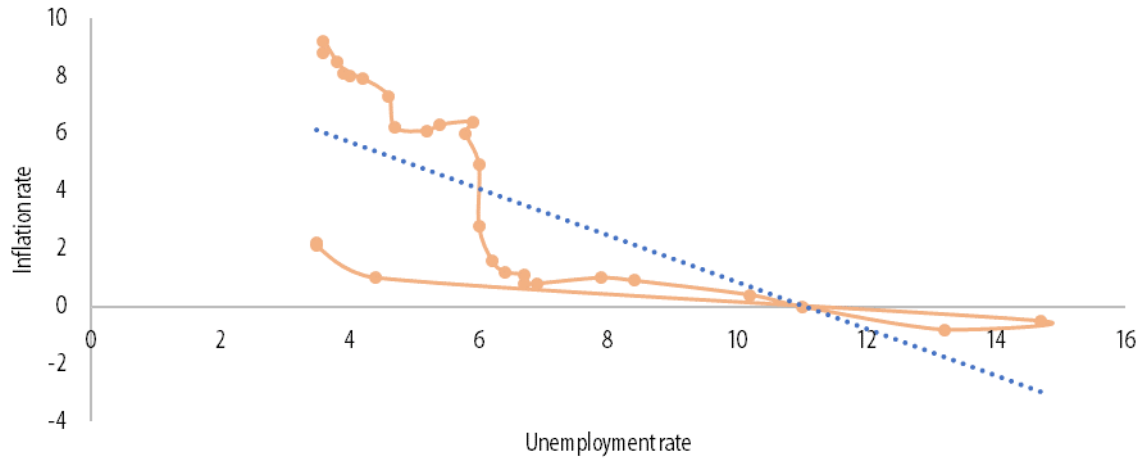

Figure 7. Relationships between inflation and unemployment rates (in per cent) in the United States from January 2020 to April 2022 (linear trend)

Source: as for Table 2.

Figure 8. Relationships between inflation and unemployment rates (in per cent) in Japan from January 2020 to April 2022 (linear trend)

Source: as for Table 2.

In the period extended beyond the economic crisis, trend slopes of the curves constructed on the pattern of the Phillips curve were also clearly negative (see Figures 7–9). Nonetheless, unemployment and inflation substitution (as an attempt at choosing the lesser evil) would currently be impossible by applying traditional macroeconomic policy instruments that impact aggregate demand, as was proposed until the first half of the 1970s, when the Phillips curves were also negatively sloped. This is because inflation is nowadays largely driven by cost-push factors. Thus, combatting inflation through contractionary fiscal and/or monetary policies could trigger inflation even more[2].

2 Algebraic analyses of contemporary Phillips curves are based on additional exogenous variables that may affect inflation. The most commonly studied factors include expected inflation, inertia reflecting

Figure 9. Relationships between inflation and unemployment rates (in per cent) in Germany from January 2020 to April 2022 (linear trend)

Source: as for Table 2.

Conclusion

The article extends research in the literature before 2020, offering additional value by examining the period of the COVID–19 pandemic, which precipitated an economic crisis. Our analysis allows us to draw several important conclusions:

1. Phillips curves, renowned in economic theory, were traditionally depicted as either negatively sloped (running down) or vertical. The former are known as short-run and the latter as long-run Phillips curves. However, the emergence of stagflation in the economic reality suggested the possibility of positively sloped (running up) curves. That may happen when an economic crisis is caused by decreased aggregate supply, which occurred as a result of consecutive lockdowns due to the COVID–19 restrictions. Therefore, we proposed a hypothesis that both unemployment and inflation should rise, and thus, relationships between the variables should be positive (unidirectional) in the United States, Japan and Germany during the economic crisis that lasted from the 1st quarter of 2020 to the end of the 1st quarter of 2021.

2. The analysis indicated that the hypothesis ought to be unequivocally rejected for all three analysed countries. Although the anticyclical unemployment rate variable showed an upward trend during the analysed period, the inflation rate trend was downward, mainly because of the significant fall in raw material prices. Thus, negatively

prior period inflation, the marginal cost measure (Nason and Smith 2008, pp. 363–365), output, expected output growth (Mankiw and Reis 2002, pp. 1299–1301), the output gap (Baranowski 2011, p. 320) and inflation caused by supply shocks (Eller and Gordon 2002, pp. 13–16). Analysis of those variables, however, goes beyond the scope of this article.

sloped Phillips curves were not entirely due to demand factors, which was highlighted in the original versions of the Phillips curve created in the 20th century.

3. Even extending the study period to include the time when real GDP started to recover despite the stringent COVID–19 pandemic restrictions still in force (from April 2021 to April 2022) would not result in the need to change the conclusions as the Phillips curves were still clearly running down (negatively sloped) in the studied countries from January 2020 to April 2022, despite unemployment showing a downward trend since the 2nd quarter of 2021. At the same time, however, strong reflationary processes were observed globally, mainly due to costs associated with a very strong upward rebound of raw material prices. Combatting cost-push inflation is particularly difficult, and thus, it is impossible to apply unemployment and inflation substitution in an attempt to choose the lesser evil, which was highlighted in the Phillips curve analyses in the 1970s.

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Zależności między inflacją a bezrobociem w Stanach Zjednoczonych, Japonii i Niemczech w czasie kryzysu gospodarczego wywołanego pandemią COVID–19

Celem artykułu jest wyjaśnienie kontrowersji dotyczących zależności między inflacją a bezrobociem w trzech najważniejszych pod względem ekonomicznym (oprócz Chin) państwach świata, tj. Stanach Zjednoczonych, Japonii i Niemczech, w czasie pandemii koronawirusa (od stycznia 2020 do lutego 2022 r.). Pandemia ta wywołała szereg niekorzystnych następstw na świecie, w tym poważny kryzys gospodarczy trwający od I kwartału 2020 do końca I kwartału 2021 r. Do podstawowych jego przyczyn należy zaliczyć spadki agregatowej podaży spowodowane lockdownami w wielu gałęziach gospodarki, związanych przede wszystkim z sektorem usług. Spadek agregatowej podaży powinien powodować nie tylko wzrost bezrobocia, ale także wzrost inflacji. W artykule postawiono w związku z tym hipotezę, że zależności między bezrobociem a inflacją w badanych krajach w ww. okresie były jednokierunkowe. W celu jej weryfikacji zastosowano dwie podstawowe metody badawcze: analizę współczynników korelacji między ww. zmiennymi oraz kształtu tzw. krzywych Phillipsa. Ostatecznie powyższą hipotezę odrzucono z uwagi na to, że inflacja w tym czasie wykazywała tendencję malejącą (przede wszystkim ze względu na znaczący spadek cen surowców). Artykuł jest uzupełnieniem badań prezentowanych w literaturze przedmiotu przed 2020 r., a jego wartością dodaną jest badanie okresu pandemii, która spowodowała kryzys gospodarczy. W przyszłości analizę należałoby poszerzyć o większą liczbę zmiennych (w tym o lukę produkcyjną), zgodnie z New Keynesian Phillips Curve.

Słowa kluczowe: bezrobocie, inflacja, krzywa Phillipsa, kryzys gospodarczy, pandemia

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.12

Analysis of Seasonal Patterns in the Performance of Fuel Markets in the Visegrad Group

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Abstract

The objective of the paper is to examine seasonal patterns in the performance of fuel markets in the Visegrad Group (V4) countries (i.e., the Czech Republic, Hungary, Poland, and Slovakia). Unlike numerous papers that investigate global oil markets, this study focuses on regional retail fuel markets. The dataset consists of weekly Pb95 gasoline and diesel prices from January 2016 through December 2020. The methods applied cover a range of statistical and econometric tools, such as the Wilcoxon rank sum test, simple regression, and the generalized autoregressive conditional heteroscedasticity (GARCH) models. The research refers to important calendar effects such as the month-of-the-year effect and the Halloween effect, but it also considers the seasonal gasoline transition effect. The empirical analysis presented in this paper does not bring clear evidence for significant seasonal patterns in the performance of fuel markets in the Visegrad Group as the application of different methods provides mixed results. Nevertheless, the findings of the Wilcoxon test are consistent with the GARCH (1, 1) estimates, which detected an April effect for gasoline and a December effect for diesel in Poland. The simple regression and GARCH (1, 1) estimates are consistent for an October effect for gasoline in Slovakia. None of the methods applied allows us to find a significant Halloween effect, a reverse Halloween effect, or a gasoline seasonal transition effect on the fuel markets of the Visegrad Group. These findings bring new insight into the V4 fuel markets and may be important for oil processing firms, retail traders, transport and distribution companies, farmers, and individual consumers.

Received: 31.03.2023. Verified: 18.10.2023. Accepted: 2.04.2024

Keywords: fuel market, seasonal patterns, Visegrad Group, Wilcoxon test, regression, GARCH model

JEL: C10, C58, Q02

Introduction

Gasoline retail markets have traditionally attracted a lot of attention from policymakers, producers, retail traders and consumers, but also from researchers. There are many contributing factors that impact fuel prices, such as the exterior costs of oil, fuel companies' margins, or natural disasters (like hurricanes), which can increase prices by disrupting transport routes or damaging refineries and other infrastructure. The currency market has an impact, too. Alongside economic conditions, there is another factor behind the alterations in price – the season. Research conducted by the Association for Convenience and Fuel Retailing (NACS) in the U.S. explained that prices in North America tend to go up in spring, starting around Memorial Day (the last Monday in May).

There are many reasons behind the increase in summer fuel prices. First, more people are traveling; in particular, families tend to take vacations and other trips during the summer, which increases demand and results in higher prices. Next, in the spring months, energy companies conduct maintenance of their refineries, shutting them down and limiting capacity until late May. Finally, twice every year, the fuel supply in the United States changes. This operation is known as the seasonal gasoline transition (Howstuffworks b.r.).

In warmer months, gasoline has a greater risk of evaporating from cars' fuel systems, generating additional smog and increased emissions. In order to reduce pollution, refiners produce summer-blend fuels that have lower Reid vapor pressure (RVP) or lower volatility. These blends burn cleaner and also help compensate for the limited oil supply, but they are more expensive. Refineries switch over to summer-blend production in March and April; fuel terminals are required to sell only summer gasoline from May 1, while gasoline stations must complete the changeover to summer gasoline by June 1. In winter, gasoline blends have a higher Reid vapor pressure that makes them evaporate more easily and allows gasoline to ignite more easily in cold temperatures. This blend is cheaper to produce, which results in lower gas prices at gasoline stations from late September through late April (GasBuddy b.r.).

Diesel fuel also exhibits some seasonality, but the effect is smaller. At one time, diesel prices were correlated to the heating oil market, which meant higher diesel prices in winter. This is no longer the case as large equipment and truck use dominate the diesel market. However, in winter, prices for diesel fuel are usually lower than during the rest of the year (Ibendhal 2019).

According to the U.S. Energy Information Administration (U.S. Energy Information Administration b.r.), crude oil is the largest component of the retail price of gasoline. Some recent studies indicate there are certain seasonal patterns in oil price behavior. These patterns are referred to as calendar anomalies. The best recognized are the day-of-the-week, the month-of-the-year, the turn-of-the-month, and the Halloween effects. For example, Yu and Shih (2011) investigated the West Texas Intermediate (WTI) daily closing spot prices of crude oil from 1986 through 2007 and found a positive Wednesday effect. Górska and Krawiec (2015) analyzed daily closing prices of crude oil from WTI and Brent from 2000 through 2014 and revealed significantly different returns on Monday and Friday and significantly different returns in February. Borowski (2016) examined crude oil futures contracts quoted on the New York Mercantile Exchange from 1983 through 2016 and discovered significantly different returns in November as well on Thursday and Friday. Burakov, Freidin, and Solovyev (2018) explored monthly closing prices of crude oil from 1985 through 2016 and reported a significant Halloween effect. Arendas, Tkacova, and Bukoven (2018) investigated Brent and WTI monthly prices from 1983 through 2017 and showed abnormal positive returns in March, April, and August and abnormal negative returns in October and November.

To the best of our knowledge, relatively little work has been done to examine calendar effects in fuel retail markets. For example, Valadkhani (2013) used daily retail prices of unleaded petrol in 114 locations across Australia from January 2005 to April 2012 to search for the day-of-the-week effect. He observed that prices mostly peaked on Thursday/Friday and then declined until they hit their cyclical lowest prices, mainly on Sunday/Tuesday. However, these daily differences were only statistically significant in capital cities or large regional centers. Rosado, Guerra, and Ferreira (2020) employed gasoline and diesel total daily sales in liters from January 2001 through 2018 in Portalegre (Portugal). They explored seasonality between morning and afternoon shifts, as well as the seasonality on weekdays and in months. They found significantly higher sales of gasoline in the afternoon, and significantly higher sales of diesel in the morning. Next, the analysis of weekdays allowed them to state that, in several cases, the sales were higher at the end of the season than at the beginning (although diesel exhibited different behavior). Moreover, the highest sales were observed on Friday. Finally, their analysis of monthly seasonality revealed that December and October seemed to be the best months for sales.

This paper examines seasonal patterns in the performance of fuel markets in the Visegrad Group (V4) countries (the Czech Republic, Hungary, Poland, and Slovakia) from January 2016 through December 2020. The Visegrad Group was established in 1991. The V4 countries cooperate in various areas of systemic reforms and social changes, science and education, culture, regional development, security, and in the area of energy and transport (Ambroziak et al. 2020). As the dataset used for the research covers gasoline Pb95 and diesel fuel weekly prices, it makes analyzing weekday effects impossible. That is why we focus on examining the month-of-the-year and the Halloween

effects. The month-of-the-year effect holds that returns expected on traded assets differ statistically by the month of the year. Empirical studies have documented that stock market returns are often much higher in January than in other months; this effect is commonly known as the January effect. Other monthly effects are the May effect (low returns) and the September effect (high returns). The Halloween effect is an anomaly in which the months of November through April provide higher returns than the remaining months of the year.

The paper contributes to the existing literature in several ways. First of all, in contrast to the majority of papers that examine calendar effects on global oil markets, we focus on regional retail fuel markets. Next, to search for calendar effects, we apply a range of different methods, including the Wilcoxon rank sum test, simple regression, and generalized autoregressive conditional heteroscedasticity (GARCH) models. Finally, we check whether the seasonal gasoline transition effect observed in the U.S. market is also present in the Visegrad Group. The paper is organized as follows. The next two sections present the methodology and the detailed results. The last section offers concluding remarks.

Methodology

Two-sample t-test

The simplest way to detect calendar effects is to run the two-sample *t*-test and to verify

H_0: $E(r_1) = E(r_2)$

against

H_1: $E(r_1) \neq E(r_2)$.

The test statistic is given by (Osińska 2006):

$$t = \frac{\bar{r}_1 - \bar{r}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}, \tag{1}$$

where $\bar{r}_1$ is the arithmetic mean calculated for sample 1 (for example, January returns),

$\bar{r}_2$ is the arithmetic mean calculated for sample 2 (for example, February returns),

S_1^2 is the variance calculated for the first sample (January returns),

S_2^2 is the variance calculated for the second sample (February returns), and n_1 and n_2 are the numbers of observations, respectively, in the first and the second samples. For large samples, the *t*-statistic follows the normal distribution.

Wilcoxon rank sum test

It often happens that commodity returns do not follow a normal distribution, so instead of the two-sample *t*-test, the non-parametric Wilcoxon rank sum test can be used to verify whether the returns differ significantly. The Wilcoxon rank sum test allows us to compare two distributions without having to make assumptions about the nature of distributions, whether normal or not. In special cases, both distributions are identical in terms of shape and dispersion, differing only in the median value. This test is much less sensitive to outliers than the two-sample *t*-test, and it reacts to other differences between the distributions, such as differences in shape. When the assumptions of the two-sample *t*-test hold, the Wilcoxon rank sum test is somewhat less likely to detect a location shift than the two-sample *t*-test. However, the losses in this regard are usually quite small (Wild and Seber 2000).

For samples of observations from each of two populations 1 and 2 containing n_1 and n_2 observations, respectively, we test the hypothesis that the distribution of X-measurements in population 1 is the same as that in 2. The Wilcoxon test is based on ranking the $n_1 + n_2$ observations of the combined sample.

The test statistic of the Wilcoxon rank sum test is the sum of the ranks for observations from one of the samples (w_1). For larger samples (n > 10), we can use the boundary normal distribution N(μ_1 , σ_1), where:

$$\mu_1 = \frac{n_1\left(n_1 + n_2 + 1\right)}{2} \tag{2}$$

and

$$\sigma_1 = \sqrt{\frac{n_1 n_2\left(n_1 + n_2 + 1\right)}{12}}. \tag{3}$$

The test statistic *z* is:

$$z = \frac{w_1 - \mu_1}{\sigma_1} \sim N\left(0,1\right). \tag{4}$$

Simple regression

To investigate specific month effects, Borges (2009) suggests estimating the simple regression equations:

$$r_t = \beta_0 + \beta_{i1} M_{it} + \varepsilon_t, \tag{5}$$

where

r_t – continuously compounded monthly returns,

β_0, β_1 – model parameters,

ε_t – error term. Here, one needs twelve different dummies: *Mi* (*i* = 1, …, 12). Each takes the value of 1 if the return is of January, February etc., and 0 otherwise. The *t*-test of β_1 tells us if this effect is significant.

Generalized autoregressive conditional heteroscedasticity (GARCH) model

In order to investigate calendar effects, GARCH models may also be applied. Numerous studies show that the GARCH (1, 1) model is a robust version of this family of models for estimating volatility (Rosini and Shenai 2020). However, it is necessary to first perform a test of ARCH effects. The ARCH(q) test proposed by Engle (1982) considers the following model:

$$\varepsilon_t^2 = \lambda_0 + \sum_{i=1}^{q} \lambda_i \varepsilon_{t-1}^2 + \zeta_t \tag{6}$$

and the following null hypothesis:

H_0: $\lambda_1 = \lambda_2 = \ldots = \lambda_q = 0$

is tested against the alternative hypothesis:

H_1: $\exists_i \lambda_i \neq 0$.

The test statistic LM is:

$$LM = T \cdot R^2, \tag{7}$$

where T denotes the number of observations and R^2 is the coefficient of determination for equation (6). The statistic follows an asymptotic chi-squared distribution with *q* degrees of freedom.

After detecting ARCH effects, one can estimate the following GARCH (1, 1) model with dummy variables:

$$r_t = \sum_{i=1}^{12} b_i M_{it} + \varepsilon_t \text{ with } \varepsilon_t \,|\, \Omega_{t-1} : N\left(0, \sigma_t^2\right), \tag{8}$$

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2, \tag{9}$$

$$\varepsilon_t = z_t \sigma_t \text{ with } z_t \text{ is i.i.d. and } z_t \sim \mathrm{N}(0, 1). \tag{10}$$

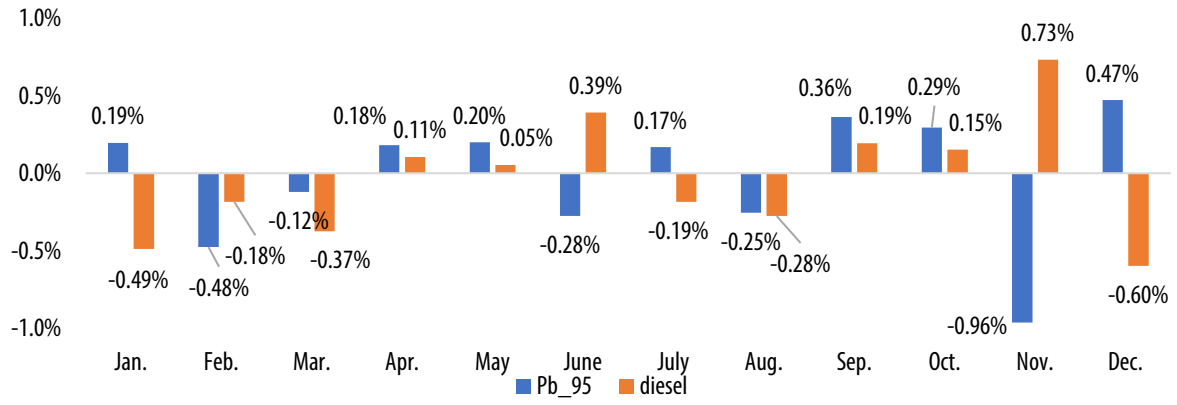
We impose ω > 0, α > 0, and β > 0 to ensure that the conditional variance (σ_t^2) is positive. If $\alpha + \beta < 1$, then the process ε_t is covariance stationary. z_t is a series of independently and identically distributed (i.i.d.) random variables with zero mean and unit variance (Qi and Wang 2013).

Empirical results

The month-of-the-year effect

In the first step of the research, we examine monthly average returns to test for the month-of-the-year effects. Average monthly Pb95 and diesel returns in the Czech Republic, Hungary, Poland and Slovakia from 2016 to 2020 are displayed in Figure 1. They were estimated on the basis of weekly prices (260 observations) expressed in domestic currencies per liter. The original data is provided by e-petrol.pl (n.d.) and published every Wednesday at 3 pm.

(a)



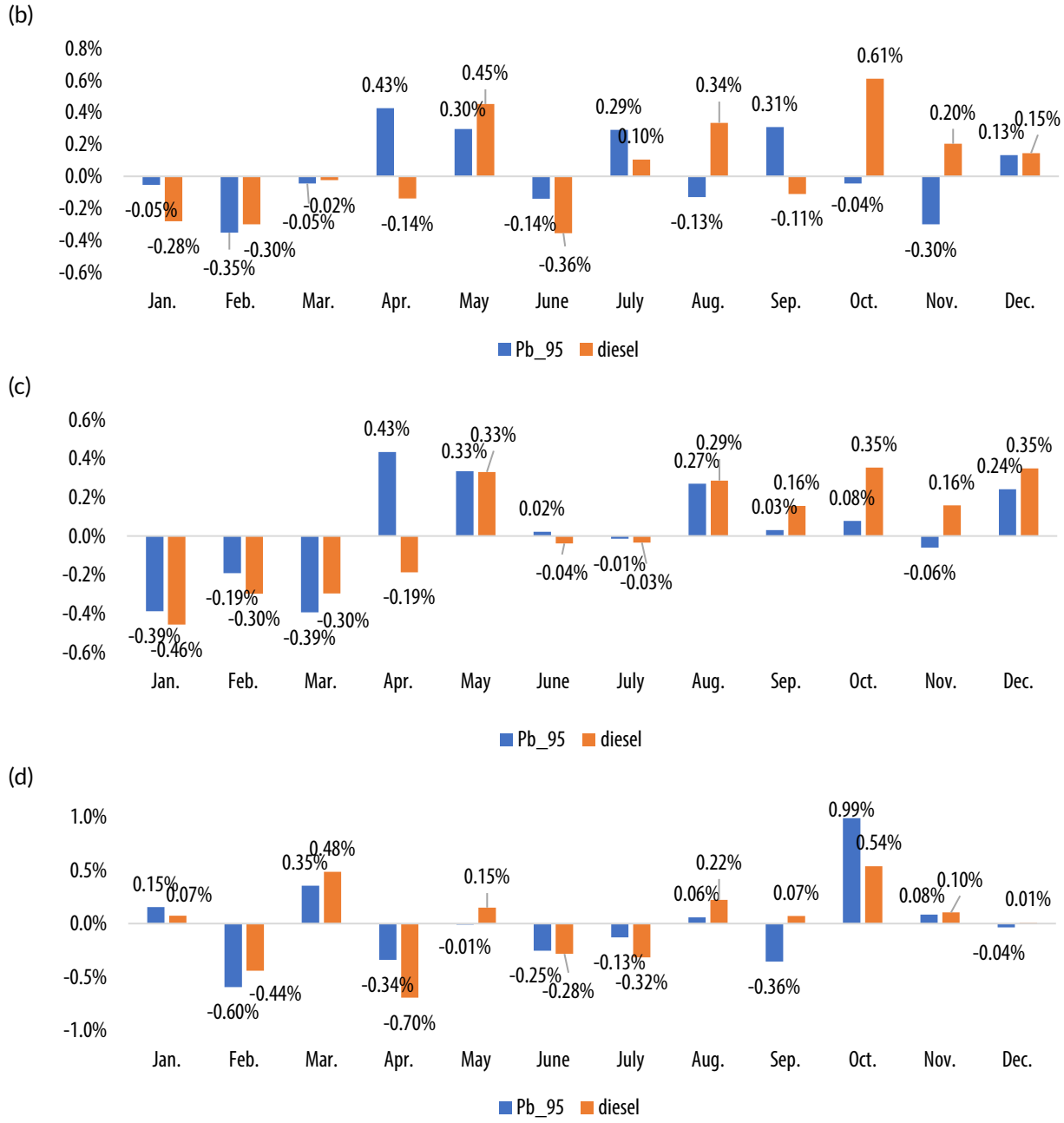


Figure 1. Average monthly Pb95 gasoline and diesel returns in the Czech Republic (a), Hungary (b), Poland (c) and Slovakia (d) from 2016 to 2020

Source: own elaboration based on data provided by e-petrol (n.d.).

For the Czech Republic, Figure 1 reveals positive gasoline average returns in January, April, May, July, September, October, and December, as well as positive diesel average returns in April, May, June, September, October, and November. For Hungary, there are positive gasoline average returns in April, May, July, September, and December and positive diesel average returns in May, July, August, October, November, and December. In Poland, positive gasoline average returns are observed in April, May, June, August, September, October, and December and positive diesel average returns in May,

August, September, October, November, and December. Finally, for Slovakia, positive gasoline average returns are reported in January, March, August, October, and November and positive diesel average returns in January, March, May, August, September, October, November, and December. Thus, based on Figure 1, we cannot find patterns in gasoline and diesel monthly average returns that are common for all V4 countries, except negative average gasoline and diesel returns in February and positive average diesel returns in May, October, and November.

Next, for each dataset covering monthly returns, we perform the Shapiro–Wilk normality test[1] to determine which statistical test (the two-sample *t*-test or the Wilcoxon rank sum test) is more robust. The results are reported in Tables 1 and 2. In numerous cases, they suggest rejection of the null hypothesis that the distributions of monthly fuel returns follow a normal distribution, so in our opinion, the Wilcoxon rank sum test is more appropriate for our data. The results of this test are given in Tables 3 and 4.

Table 1. The Shapiro–Wilk test results for Pb95 gasoline monthly returns

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January	0.945 (0.25)	0.906 (0.04)	0.970 (0.70)	0.572 (0.00)
February	0.877 (0.02)	0.794 (0.00)	0.880 (0.02)	0.690 (0.00)
March	0.925 (0.10)	0.929 (0.12)	0.935 (0.16)	0.793 (0.00)
April	0.935 (0.17)	0.935 (0.17)	0.958 (0.48)	0.564 (0.00)
May	0.956 (0.39)	0.879 (0.01)	0.944 (0.22)	0.747 (0.00)
June	0.887 (0.02)	0.757 (0.00)	0.793 (0.00)	0.785 (0.00)
July	0.877 (0.01)	0.969 (0.70)	0.964 (0.58)	0.898 (0.03)
August	0.972 (0.74)	0.948 (0.27)	0.953 (0.34)	0.646 (0.00)
September	0.676 (0.00)	0.967 (0.66)	0.934 (0.16)	0.592 (0.00)

1 This test, proposed by Shapiro and Wilk in 1965, is commonly used for small samples. The null hypothesis of this test is that the population is normally distributed.

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
October	0.849 (0.00)	0.945 (0.25)	0.886 (0.02)	0.586 (0.00)
November	0.923 (0.09)	0.955 (0.40)	0.686 (0.00)	0.839 (0.00)
December	0.879 (0.02)	0.896 (0.03)	0.903 (0.04)	0.576 (0.00)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 2. The Shapiro–Wilk test results for diesel monthly returns

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January	0.974 (0.80)	0.865 (0.01)	0.949 (0.30)	0.585 (0.00)
February	0.957 (0.49)	0.733 (0.00)	0.960 (0.55)	0.672 (0.00)
March	0.925 (0.10)	0.902 (0.03)	0.914 (0.06)	0.802 (0.00)
April	0.934 (0.17)	0.713 (0.00)	0.961 (0.53)	0.551 (0.00)
May	0.989 (0.99)	0.931 (0.12)	0.916 (0.05)	0.811 (0.00)
June	0.792 (0.00)	0.958 (0.47)	0.773 (0.00)	0.643 (0.00)
July	0.949 (0.30)	0.897 (0.03)	0.977 (0.85)	0.469 (0.00)
August	0.890 (0.02)	0.847 (0.00)	0.931 (0.11)	0.627 (0.00)
September	0.922 (0.09)	0.919 (0.08)	0.864 (0.01)	0.375 (0.00)
October	0.919 (0.07)	0.866 (0.01)	0.961 (0.50)	0.379 (0.00)
November	0.923 (0.09)	0.980 (0.91)	0.879 (0.01)	0.829 (0.00)
December	0.874 (0.01)	0.902 (0.05)	0.897 (0.04)	0.525 (0.00)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 3. Monthly effects for Pb95 gasoline – the Wilcoxon rank sum test

Pair	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January – February	–0.907 (0.37)	–1.020 (0.31)	0.038 (0.97)	–0.667 (0.51)
January – March	0.528 (0.60)	0.493 (0.62)	0.070 (0.94)	–1.033 (0.30)
January – April	–0.510 (0.61)	0.960 (0.34)	2.235 (0.03)	1.118 (0.26)
January – May	0.068 (0.95)	–0.920 (0.36)	–1.567 (0.12)	–0.341 (0.73)
January – June	–0.292 (0.77)	–1.263 (0.21)	0.535 (0.59)	0.340 (0.73)
January – July	–0.070 (0.94)	–0.939 (0.35)	–1.221 (0.22)	0.200 (0.84)
January – August	0.602 (0.55)	0.363 (0.72)	–2.157 (0.03)	–0.409 (0.68)
January – September	0.535 (0.59)	0.462 (0.64)	1.361 (0.17)	–0.510 (0.61)
January – October	–0.669 (0.50)	0.786 (0.43)	–1.291 (0.20)	–1.526 (0.13)
January – November	1.373 (0.17)	0.974 (0.33)	–1.174 (0.24)	–0.293 (0.77)
January – December	0.844 (0.40)	0.730 (0.47)	2.405 (0.02)	0.176 (0.86)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 4. Monthly effects for diesel – the Wilcoxon rank sum test

Pair	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January – February	–0.013 (0.99)	0.050 (0.96)	0.113 (0.91)	–0.113 (0.91)
January – March	–0.141 (0.89)	–0.516 (0.61)	–0.493 (0.62)	–1.631 (0.10)
January – April	0.097 (0.92)	1.604 (0.11)	0.425 (0.67)	–0.741 (0.46)
January – May	–0.454 (0.65)	–1.453 (0.15)	–1.419 (0.16)	–0.795 (0.43)

Pair	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January – June	0.765 (0.44)	–0.292 (0.77)	0.413 (0.68)	0.389 (0.70)
January – July	–0.293 (0.77)	–0.704 (0.48)	–0.915 (0.36)	0.634 (0.53)
January – August	–0.182 (0.86)	–1.135 (0.26)	–1.555 (0.12)	–0.284 (0.78)
January – September	0.267 (0.79)	0.413 (0.68)	1.652 (0.10)	0.255 (0.80)
January – October	–0.634 (0.53)	–1.948 (0.05)	–1.878 (0.06)	–0.657 (0.51)
January – November	–1.303 (0.19)	–0.704 (0.48)	–1.514 (0.13)	–0.035 (0.97)
January – December	0.063 (0.95)	1.662 (0.10)	2.569 (0.01)	–0.227 (0.82)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

The Wilcoxon rank sum test results show that only in Poland does the average January gasoline return differ significantly from April, August and December's average returns. The average January diesel return is significantly different from the December return (at the 0.05 level).

Next, to investigate individual month-of-the-year effects, we estimate simple regressions. The results for β_{i1} coefficients are set in Tables 5 and 6. They reveal a significant positive October effect for Pb95 gasoline in Slovakia and a significant negative April effect for diesel in Slovakia (at the 0.05 level).

Table 5. Monthly effects for Pb95 gasoline – simple regression

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January	0.0036 (0.52)	–0.0002 (0.95)	–0.0039 (0.17)	0.0023 (0.58)
February	–0.0051 (0.39)	–0.0043 (0.26)	–0.0025 (0.40)	–0.0064 (0.15)
March	–0.0013 (0.82)	–0.0010 (0.79)	–0.0042 (0.13)	0.0038 (0.37)
April	0.0011 (0.86)	0.0028 (0.46)	0.0031 (0.29)	–0.0053 (0.22)

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
May	0.0024 (0.67)	0.0029 (0.42)	0.0031 (0.27)	0.0006 (0.88)
June	−0.0027 (0.64)	−0.0020 (0.60)	0.00004 (0.99)	−0.0023 (0.59)
July	0.0020 (0.73)	0.0033 (0.36)	−0.0005 (0.87)	−0.0017 (0.68)
August	−0.0025 (0.65)	−0.0017 (0.64)	0.0026 (0.35)	0.0009 (0.833)
September	0.0038 (0.51)	0.0028 (0.46)	0.0001 (0.98)	−0.0036 (0.40)
October	0.0034 (0.55)	−0.0013 (0.72)	0.0002 (0.93)	0.0101 (0.02)
November	−0.0101 (0.07)	−0.0033 (0.37)	−0.0010 (0.73)	0.0008 (0.85)
December	0.0055 (0.35)	0.0020 (0.61)	0.0030 (0.31)	−0.0003 (0.94)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 6. Monthly effects for diesel – simple regression

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
January	−0.0036 (0.63)	−0.002 (0.54)	−0.0041 (0.10)	0.0015 (0.71)
February	−0.0018 (0.82)	−0.004 (0.30)	−0.0037 (0.16)	−0.0048 (0.23)
March	−0.0040 (0.60)	−0.001 (0.79)	−0.0031 (0.22)	0.0054 (0.17)
April	0.0006 (0.93)	−0.003 (0.39)	−0.0034 (0.19)	−0.0087 (0.03)
May	0.0011 (0.88)	0.0041 (0.27)	0.0029 (0.24)	0.0019 (0.63)
June	0.0047 (0.55)	−0.0044 (0.26)	0.0005 (0.85)	−0.0025 (0.53)
July	−0.0016 (0.84)	0.0006 (0.87)	−0.0009 (0.73)	−0.0037 (0.34)
August	−0.0032 (0.67)	0.0027 (0.47)	0.0027 (0.28)	0.0026 (0.49)

Month	Country			
	Czech Rep.	Hungary	Poland	Slovakia
September	0.0019 (0.80)	–0.0021 (0.57)	0.0011 (0.67)	0.0007 (0.86)
October	0.0021 (0.79)	0.0055 (0.14)	0.0032 (0.20)	0.0054 (0.17)
November	0.0090 (0.24)	0.0014 (0.71)	0.0012 (0.34)	0.0013 (0.73)
December	–0.0054 (0.49)	0.0022 (0.58)	0.0042 (0.11)	0.0001 (0.99)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

In the next stage of the research, we test the presence of ARCH effects in the data. The results are given in Table 7. Regardless of the number of lags, we cannot reject the null hypothesis for diesel in Slovakia, so there is no reason to estimate GARCH models based on the data. Moreover, in the case of Pb95 gasoline returns in the Czech Republic, matrix was not positive definite. Thus, Table 8 presents GARCH (1, 1) estimates for gasoline returns in Hungary, Poland, and Slovakia and diesel returns in the Czech Republic, Hungary, and Poland.

Table 7. ARCH(q) test for Pb95 gasoline and diesel

Fuel	q		
	1	4	12
Czech Rep. Pb95	1.18 (0.27)	11.89 (0.02)	24.77 (0.02)
Hungary Pb95	1.68 (0.19)	8.22 (0.08)	31.59 (0.00)
Poland Pb95	29.55 (0.00)	35.23 (0.00)	35.18 (0.00)
Slovakia Pb95	0.59 (0.44)	12.26 (0.02)	14.85 (0.24)
Czech Rep. diesel	8.68 (0.003)	86.42 (0.00)	20.18 (0.06)
Hungary diesel	12.92 (0.00)	13.13 (0.01)	16.69 (0.16)
Poland diesel	10.14 (0.00)	14.59 (0.01)	24.93 (0.01)

Fuel	q		
	1	4	12
Slovakia diesel	0.01 (0.94)	1.03 (0.91)	2.33 (0.99)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 8. Monthly effects for Pb95 gasoline and diesel – GARCH (1, 1) approach

Estimate	Hungary Pb95	Poland Pb95	Slovakia Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel
b_1	0.0015 (0.64)	–0.0020 (0.19)	0.0027 (0.43)	0.0047 (0.50)	–0.00002 (0.99)	–0.0012 (0.48)
b_2	–0.0058 (0.10)	0.0009 (0.60)	–0.0057 (0.12)	–0.0020 (0.69)	–0.0030 (0.39)	–0.0023 (0.11)
b_3	0.0029 (0.44)	0.0051 (0.01)	0.0046 (0.23)	–0.0026 (0.50)	0.0002 (0.96)	0.0083 (0.00)
b_4	0.0090 (0.44)	0.0095 (0.00)	–0.0010 (0.81)	0.0021 (0.72)	0.0022 (0.52)	0.0022 (0.35)
b_5	0.0061 (0.01)	0.0073 (0.00)	0.0032 (0.40)	0.00003 (0.99)	0.0088 (0.01)	0.0060 (0.00)
b_6	–0.0037 (0.29)	–0.0019 (0.34)	0.0024 (0.63)	0.0191 (0.00)	–0.0035 (0.34)	–0.0023 (0.37)
b_7	0.0023 (0.48)	–0.0022 (0.22)	–0.0046 (0.20)	0.0042 (0.41)	0.0013 (0.71)	0.0006 (0.77)
b_8	–0.0009 (0.74)	0.0027 (0.15)	0.0009 (0.78)	0.0052 (0.36)	0.0065 (0.03)	0.0049 (0.02)
b_9	0.0032 (0.27)	0.0001 (0.96)	–0.0034 (0.34)	–0.0005 (0.92)	–0.0006 (0.85)	0.0015 (0.31)
b_{10}	–0.0013 (0.69)	–0.0034 (0.00)	0.0096 (0.02)	0.0020 (0.61)	0.0079 (0.01)	0.0029 (0.13)
b_{11}	–0.0020 (0.53)	0.0013 (0.34)	0.0005 (0.89)	–0.0003 (0.94)	0.0020 (0.51)	0.0020 (0.16)
b_{12}	0.0033 (0.30)	0.0033 (0.05)	–0.0010 (0.79)	0.0056 (0.23)	0.0036 (0.27)	0.0070 (0.00)
$\hat{\omega}$	0.00004 (0.01)	0.00001 (0.02)	0.0001 (0.01)	0.0003 (0.02)	0.0002 (0.00)	0.00003 (0.00)
$\hat{\alpha}$	0.1244 (0.01)	0.5569 (0.00)	0.1078 (0.03)	0.5804 (0.00)	0.3004 (0.00)	0.7026 (0.00)

Estimate	Hungary Pb95	Poland Pb95	Slovakia Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel
$\hat{\beta}$	0.7174 (0.00)	0.4431 (0.00)	0.6929 (0.00)	0.2681 (0.08)	0.0954 (0.35)	0.1679 (0.03)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

The results reported in Table 8 reveal several monthly effects that are significant at the 0.05 level: the March effect for gasoline and diesel in Poland, the April effect for gasoline in Poland, the May effect for gasoline and diesel in Hungary and Poland, the June effect for diesel in the Czech Republic, the August effect for diesel in Hungary and Poland, the October effect for gasoline in Poland and Slovakia, and diesel in Hungary, and the December effect for diesel in Poland. All these estimates are statistically significantly positive, except for the October average monthly gasoline return in Poland.

The Halloween effect

The second part of the research investigates the Halloween effect. Following Bouman and Jacobsen (2002), who were the first to describe this effect, we define two separate periods: winter (November to April) and summer (May to October). Average returns for these particular periods are displayed in Figure 2.

Figure 2 shows positive average summer gasoline and diesel returns in all countries and negative winter returns. It suggests the reverse Halloween effect. Before examining this effect, we performed the Shapiro–Wilk test. Table 9 provides the results. This time, they suggest the rejection of the null hypothesis in all cases. Thus, in the next step, we perform the Wilcoxon rank sum test (the results are reported in Table 10).

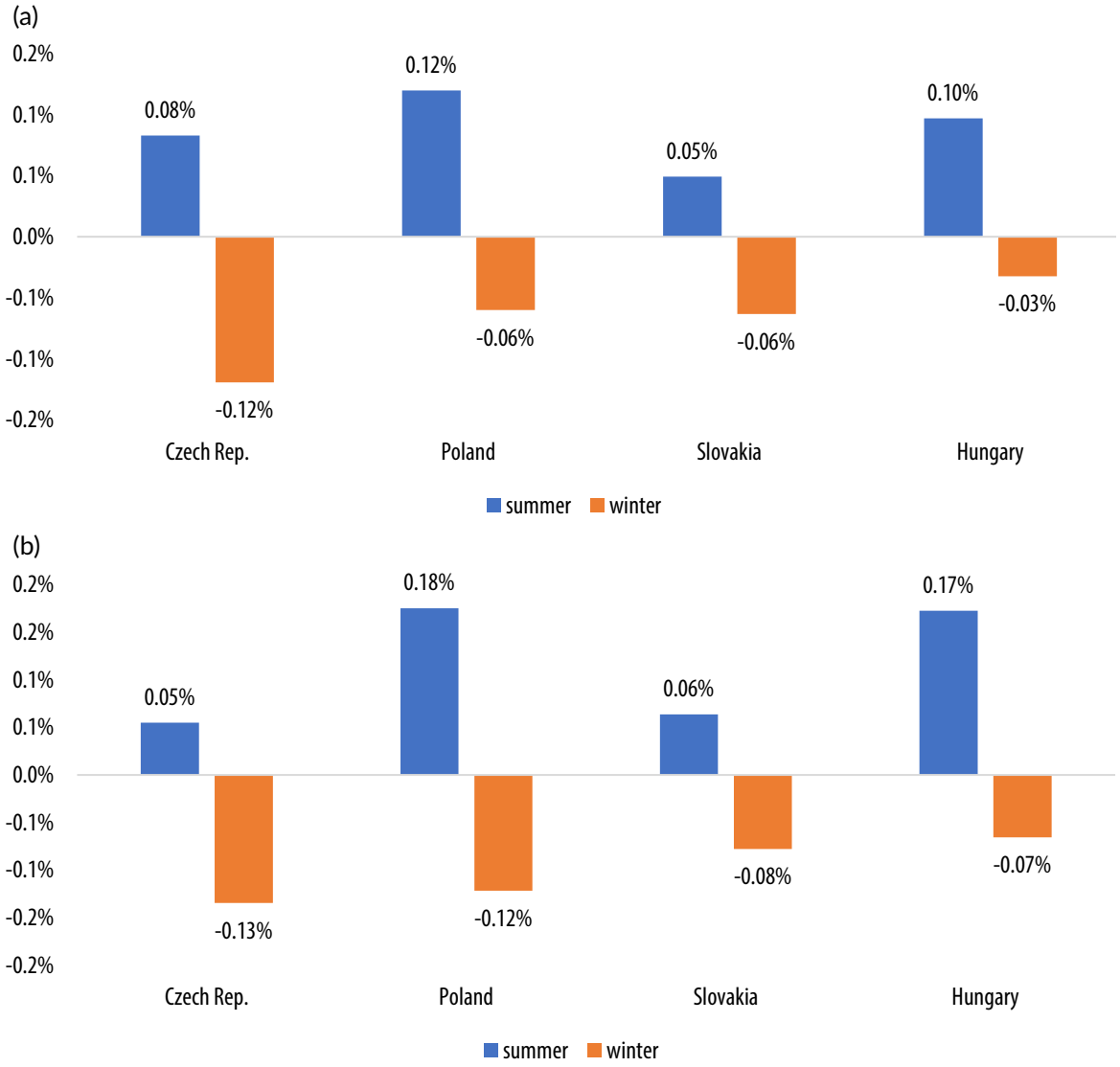


Figure 2. Average returns for particular periods (summer and winter) in the Czech Republic, Hungary, Poland and Slovakia from 2016 to 2020: Pb95 (a) and diesel (b)

Source: own elaboration based on data provided by e-petrol (n.d.).

Table 9. The Shapiro–Wilk test for particular periods (winter and summer)

Period	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel	Slovakia diesel
Winter	0.967 (0.00)	0.939 (0.00)	0.861 (0.00)	0.686 (0.00)	0.920 (0.00)	0.890 (0.00)	0.927 (0.00)	0.687 (0.00)
Summer	0.921 (0.00)	0.913 (0.00)	0.949 (0.00)	0.741 (0.00)	0.890 (0.00)	0.889 (0.00)	0.926 (0.00)	0.511 (0.00)

Note: (•) – p-value

Source: own calculations based on data provided by e-petrol (n.d.).

Table 10. The Halloween effect – the Wilcoxon rank sum test

Fuel	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel	Slovakia diesel
z	–1.146 (0.25)	–0.159 (0.87)	–0.806 (0.42)	–0.017 (0.99)	–0.299 (0.77)	–0.342 (0.73)	–1.397 (0.16)	–0.351 (0.73)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

The results given in Table 10 do not reveal any significant differences between summer and winter gasoline and diesel returns, so they detect neither Halloween nor reverse Halloween effects.

Next, we estimate simple regressions with the redefined seasonal dummy variable in equation (5), which now takes the value of 1 if month t falls in the November–April period and 0 otherwise. The results are reported in Table 11. They also do not find any significant effects.

Table 11. The Halloween effect – simple regression

Period	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel	Slovakia diesel
Winter	–0.0020 (0.53)	–0.0013 (0.54)	–0.0018 (0.27)	–0.0013 (0.58)	–0.0015 (0.73)	–0.0021 (0.31)	–0.0027 (0.05)	–0.0014 (0.51)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Finally, we estimate GARCH (1, 1) models, with the Halloween effect seasonal dummy and constant. The results provided in Table 12 do not reveal significant effects.

Table 12. The Halloween effect – GARCH (1, 1) approach

Estimate	Hungary Pb95	Poland Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel
Const.	0.0009 (0.50)	–0.0011 (0.15)	0.0025 (0.26)	0.0035 (0.02)	0.0021 (0.03)
b_1	0.0001 (0.96)	0.0038 (0.07)	–0.0021 (0.50)	–0.0028 (0.17)	–0.0013 (0.35)
$\hat{\omega}$	0.00004 (0.02)	0.00001 (0.17)	0.0003 (0.02)	0.0002 (0.00)	0.0001 (0.00)
$\hat{\alpha}$	0.0827 (0.03)	0.4556 (0.00)	0.4028 (0.00)	0.2470 (0.01)	0.2891 (0.01)

Estimate	Hungary Pb95	Poland Pb95	Czech Rep. diesel	Hungary diesel	Poland diesel
$\hat{\beta}$	0.7620 (0.00)	0.5444 (0.00)	0.3365 (0.03)	0.1030 (0.31)	0.2271 (0.10)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Seasonal gasoline transition effect

The last part of the research aims to ascertain whether the seasonal gasoline transition effect observed in the U.S. market is also present in the regional markets of the Visegrad Group. Here, we redefine summer and winter periods in the following way: winter (October–May) and summer (June–September). The average Pb95 gasoline returns for the two redefined periods are displayed in Figure 3.

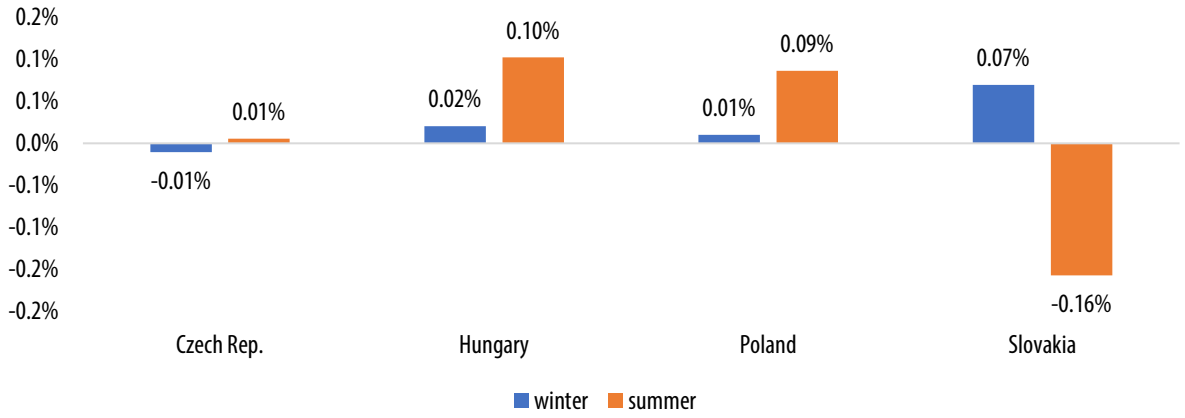


Figure 3. Average Pb95 gasoline returns for redefined periods (summer and winter) in the Czech Republic, Hungary, Poland and Slovakia from 2016 to 2020

Source: own elaboration based on data provided by e-petrol (n.d.).

Figure 3 shows positive average winter gasoline returns in V4 countries (except the Czech Republic) and positive average summer returns (except Slovakia).

For the redefined data, we perform the Shapiro–Wilk test. The results reported in Table 13 suggest rejection of the null hypothesis in all cases. Again, the Wilcoxon rank sum test is more appropriate for our data. Its results are given in Table 14. In all cases, we cannot reject the null hypothesis, so the redefined winter and summer gasoline returns do not differ significantly, suggesting there is no seasonal gasoline transition effect.

Table 13. The Shapiro–Wilk test for redefined periods (winter and summer)

Period	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95
Winter	0.961 326 (0.00)	0.943 611 (0.00)	0.869 141 (0.00)	0.697 203 (0.00)
Summer	0.900 743 (0.00)	0.895 995 (0.00)	0.961 056 (0.01)	0.743 417 (0.00)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Table 14. The seasonal transition effect – the Wilcoxon rank sum test

Fuel	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95
z	0.294 168 (0.77)	0.015 806 (0.99)	0.332 805 (0.74)	– 1.02 739 (0.30)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Next, we estimate simple regressions with a seasonal dummy, taking the value of 1 if month t falls in the June–September period and 0 otherwise. The results are reported in Table 15. They do not find a significant seasonal transition effect for the gasoline market in the Visegrad Group.

Table 15. The seasonal transition effect – simple regression

Period	Czech Rep. Pb95	Hungary Pb95	Poland Pb95	Slovakia Pb95
Summer	0.000 159 (0.96)	0.000 816 (0.71)	0.000 762 (0.65)	– 0.002 267 (0.36)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

The study ends with the estimation of the GARCH (1, 1) models with the seasonal transition effect dummy and constant for the Hungarian, Polish and Slovakian gasoline markets (for the Czech Republic, the matrix was not positive definite). The results given in Table 16 do not reveal significant seasonal transition effects in the three examined gasoline markets, either.

Table 16. The seasonal transition effect – GARCH (1, 1) approach

Estimate	Hungary Pb95	Poland Pb95	Slovakia Pb95
Const.	0.00125 (0.33)	0.00073 (0.29)	0.00137 (0.32)
b_1	–0.00078 (0.71)	–0.00045 (0.72)	–0.00288 (0.22)
$\hat{\omega}$	0.00004 (0.02)	0.00002 (0.10)	0.00008 (0.01)
$\hat{\alpha}$	0.08390 (0.0290)	0.43829 (0.0013)	0.09184 (0.0239)
$\hat{\beta}$	0.76185 (0.00)	0.54965 (0.00)	0.67807 (0.00)

Note: (•) – p-value
Source: own calculations based on data provided by e-petrol (n.d.).

Conclusion

This paper examined seasonal patterns in the performance of regional fuel markets in the Visegrad Group. The data covered Pb95 gasoline and diesel fuel weekly prices from January 2016 through December 2020. The quantitative analysis was based on logarithmic returns, and it employed a range of statistical and econometric tools, such as the Wilcoxon rank sum test, simple regressions, and the GARCH models. The research focused on investigating two important calendar effects: the month-of-the-year effect and the Halloween effect, but it also considered the seasonal gasoline transition effect. Detecting some calendar anomalies, i.e., significant variations in gasoline and diesel returns that follow certain patterns or trends over time would be of great interest to consumers as they may shift purchases to save the cost (for many consumers, expenditures on fuels occupy some significant percentage of households' disposable income).

Even though it may not be a huge benefit for those individual consumers who have to refuel their cars regularly and pay whatever the price is, farmers would be able to save some money by purchasing diesel several months ahead. For business, in particular for fleet managers, recognizing market patterns may bring several advantages. For example, if a company supplies some vehicles with fuel, the best idea is to do it when the prices of fuel are the most favorable. This kind of information could also be used by oil processing companies to increase their profitability, as the existence of seasonality makes sales more predictable. Therefore, firms may try to trigger a rise in prices just before periods of expected high demand, resulting in significantly greater average returns.

However, the research presented in this paper does not bring clear evidence for significant seasonal patterns in the performance of regional fuel markets in the Visegrad Group, as the application of different methods provides mixed results. For example, when it comes to the analysis of the month-of-the-year effects, the Wilcoxon rank sum test shows that in Poland, the average January gasoline return differs significantly from April, August, and December's average returns and the average January diesel return is significantly different from the December return. Simple regressions detect a significant positive October effect for gasoline and a significant negative April effect for diesel in Slovakia. The GARCH (1, 1) models reveal several significant monthly effects: the March effect for gasoline and diesel in Poland, the April effect for gasoline in Poland, the May effect for gasoline and diesel in Hungary and Poland, the June effect for diesel in the Czech Republic, the August effect for diesel in Hungary and Poland, the October effect for gasoline in Poland and Slovakia, and diesel in Hungary, and the December effect for diesel in Poland. Thus, the results of the Wilcoxon rank sum test are consistent with the GARCH (1, 1) estimates in the case of a gasoline April effect and a diesel December effect in Poland. Meanwhile, simple regression and GARCH (1, 1) estimates are consistent for a gasoline October effect in Slovakia. None of the methods applied found a significant Halloween effect, a reverse Halloween effect or a gasoline seasonal transition effect on the regional fuel markets of the Visegrad Group.

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Analiza sezonowych prawidłowości na rynkach paliw Grupy Wyszehradzkiej

Celem pracy jest weryfikacja występowania sezonowych prawidłowości na rynkach paliw w krajach Grupy Wyszehradzkiej (V4), tj. w Czechach, na Węgrzech, w Polsce i na Słowacji. W odróżnieniu od wielu opracowań analizujących globalne rynki ropy ta praca koncentruje się na regionalnych detalicznych rynkach paliw. Dane empiryczne stanowią średnie tygodniowe ceny benzyny bezołowiowej Pb95 oraz oleju napędowego w okresie od stycznia 2016 do grudnia 2020 roku. Wykorzystane metody obejmują szereg narzędzi statystycznych i ekonometrycznych, takich jak

test sumy rang Wilcoxona, regresja prosta oraz uogólnione modele autoregresyjne z warunkową heteroskedastycznością (GARCH). W badaniach skupiono się na analizie dwóch ważnych efektów kalendarzowych: efektu miesiąca w roku i efektu Halloween, ale uwzględniono również efekt sezonowej zmiany benzyny. Analiza empiryczna przedstawiona w pracy nie dostarczyła jednoznacznych dowodów na występowanie istotnych statystycznie prawidłowości na rynkach paliw w Grupie Wyszehradzkiej, gdyż wyniki uzyskane w konsekwencji zastosowania poszczególnych metod nie były jednoznaczne. Niemniej wnioski sformułowane na podstawie testu Wilcoxona są zgodne z wnioskami z modeli GARCH (1, 1) ujawniającymi efekt kwietnia dla benzyny i efekt grudnia dla oleju napędowego w Polsce. Ponadto wyniki regresji prostej i modelu GARCH (1, 1) wskazują efekt października dla benzyny na Słowacji. Natomiast żadna z zastosowanych metod nie pozwoliła wykryć efektu Halloween ani odwrotnego efektu Halloween czy też efektu sezonowej zmiany benzyny na rynkach paliw Grupy Wyszehradzkiej. Otrzymane wnioski dają nowy wgląd w rynki paliw Grupy Wyszehradzkiej i mogą być istotne dla podmiotów zajmujących się przetwórstwem ropy naftowej, przedsiębiorstw handlu detalicznego, firm transportowych i dystrybucyjnych, rolników czy konsumentów indywidualnych.

Słowa kluczowe: rynek paliw, sezonowe prawidłowości, Grupa Wyszehradzka, test Wilcoxona, regresja, model GARCH

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.13

Energy Policy in the European Union within the European Green Deal Strategy

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Abstract

The article presents the energy policy of the European Union (EU) in light of its latest strategy, called the European Green Deal. The article is of particular importance to answer two main questions:
What was the importance of two energy packages in the EU energy policy, i.e., the fourth and fifth packages? The fourth package was adopted in June 2019; the fifth package – "Ready for 55" – was published in 2021 and aimed to align the EU's energy targets with the new European climate targets for 2030 and 2050.
What are the main conclusions from the presented tables and graphs regarding carbon dioxide emissions in European Union countries from 2012 to 2021? Additionally, what insights can be drawn regarding changes in electricity prices for household and non-household consumers in euros per 100 kilowatt-hour, as well as gross electricity production (in million tonnes of oil equivalent) in the analyzed years for all EU Member States?

Keywords: European Union, energy policy, energy packages, countries of the EU, household and non-household consumers of energy

JEL: A19

Introduction

The European Union (EU) is actively promoting Europe's transition to a low-carbon society and is updating its rules to facilitate the necessary private and public investment in the clean energy transition. This should not only be good for the planet but also for the economy and consumers.

Received: 20.03.2023. Verified: 5.10.2023. Accepted: 2.04.2024

The increasing evidence of climate change and growing dependence on energy have underlined the determination of the EU to become the world's first climate-neutral continent and economy and ensure that the energy consumed is secure, safe, competitive, locally produced and sustainable.

These objectives are based on the energy union strategy (2015), which, together with Regulation (EU) 2018/1999 on the governance of the energy union, defines the dimensions of the EU's energy policy:

- Diversifying the EU's sources of energy, ranging from fossil fuels, through nuclear power, to renewables (solar, wind, biomass, geothermal, hydro-electric and tidal) to ensure energy security.
- Realizing a fully integrated, efficient internal energy market without technical or regulatory barriers.
- Improving energy efficiency and the interconnection of energy networks and cutting emissions.
- Moving towards a low-carbon economy in line with the commitments set out in the Paris Agreement.
- Promoting research in low-carbon and clean energy technologies and prioritizing research and innovation to drive the energy transition and improve competitiveness (European Union n.d.).

Article 194 of the Treaty on the Functioning of the European Union introduces a specific legal basis for the field of energy based on shared competencies between the EU and the EU Member States, leading them towards a common energy policy. The low-carbon transition aims to create a sustainable energy sector that stimulates growth, innovation, and jobs while improving quality of life, increasing choice, reinforcing consumer rights, and ultimately providing savings in household bills. A streamlined and coordinated EU approach ensures a genuinely continental impact in the fight against climate change. Moves to encourage renewables and improve energy efficiency are central to reducing Europe's greenhouse gas emissions and meeting Paris Agreement commitments.

Historical background

In the late 1980s, the European Commission proposed a set of policies (called directives in the EU context) on integrating the European market. One of the key ideas was that consumers could buy electricity from outside their own country. However, this plan encountered opposition from the Council of Ministers, as the policy

sought to liberalize what was regarded as a natural monopoly. The less controversial parts of the directives those on price transparency and transit right for grid operators were adopted in 1990. In November 1983, the Council of Ministers of Energy Economy, for the first time, granted the Community a power of attorney to conduct an independent energy policy (Dutton 2015, pp. 2–3). Subsequently, the EC Commission, in its report "Internal Energy Market" (May 1988), included a number of already old initiatives in the form of a program. The Working Paper on the Internal Energy Market of 1988 emphasizes that the concept of an open, internal market for electricity production implies the production of electricity under economically competitive conditions, subject only to the requirements of environmental protection and the Community's energy policy (Dutton 2015, pp. 3–5).

Start of an internal energy market

The 1992 Treaty of Maastricht, which founded the European Union, included no chapter specific on energy. Such a chapter had been rejected by member states who wanted to retain autonomy on energy, specifically those with larger energy reserves. In order to create a Western-Eastern energy alliance, in December 1994, 45 countries signed the "Treaty on the European Energy Charter", thus formulating a common catalog of goals and a code of conduct in this field. However, it has yet to be verified in practice. A directive for an internal electricity market was passed in 1996 by the European Parliament, and another on the internal gas market two years later. The directive for the electricity market contained the requirement that network operation and energy generation should not be done by a single (monopolistic) company. Having separate energy generation would allow for competition in that sector, whereas network operation would remain regulated.

Investing in a sustainable energy future for Europe

The EU is actively promoting Europe's transition to a low-carbon society and is updating its rules in order to facilitate the necessary private and public investment in the clean energy transition. This should not only be good for the planet, but also for the economy and consumers. The low-carbon transition aims to create a sustainable energy sector that stimulates growth, innovation, and jobs while improving quality of life, increasing choice, reinforcing consumer rights, and ultimately providing savings in household bills. A streamlined and coordinated EU approach ensures a genuinely continental impact in the fight against climate change. Moves to encourage renewables and improve energy efficiency are central to reducing Europe's greenhouse gas emissions and meeting Paris Agreement commitments. Through the European energy union, the EU is ensuring greater coherence in all policy areas to meet the broad objectives of creating

a reliable, affordable and sustainable energy system. The EU also provides various funding opportunities and lending schemes to help companies and regions successfully implement energy projects. The EU plays an important role on the international stage, working with other countries, regions and international organizations to tackle energy problems and ensure a reliable, competitive energy market within Europe (European Union n.d.).

Liberalization of the energy markets in the EU within the energy packages

In the 1990s, when most national electricity and natural gas markets were still monopolized, the European Union and the Member States decided to gradually open up these markets to competition. This took place as part of the six energy packages of the EU.

The first energy package was adopted between 1996 and 1998. This was the first liberalization of the national electricity and gas markets. It was based on two new directives on electricity and gas, which were to be transposed into the legal systems of the Member States by 1998 and 2000, respectively.

The second energy package was adopted in 2003, and its directives had to be transposed into national law by 2004, with some provisions entering into force in 2007. Since then, industrial consumers and Member States have been free to choose their gas and electricity suppliers from a wider range of competitors.

In 2009, the third energy package was adopted, which further liberalized the internal electricity and gas markets. It introduced a number of reforms, e.g., unbundling the supply and generation of energy from the operation of transmission networks (so-called unbundling). It also introduced requirements for independent regulatory authorities, established a new European Union Agency for the Cooperation of Energy Regulators (ACER), established European networks of electricity and gas transmission system operators (ENTSO-E and ENTSO-G), and strengthened consumer rights in retail markets. This package was the basis for the implementation of the internal energy market.

The fourth energy package was adopted in June 2019, consisting of one directive (Directive (EU) 2019/944 on electricity) and three regulations (Regulation (EU) 2019/943 on electricity, Regulation (EU) 2019/941 on risk preparedness, Regulation (EU) 2019/942 establishing a European Union Agency for the Cooperation of Regulators E 2019/942/EU). It introduced new electricity market rules to meet renewable energy needs and attract investment. It provides incentives for consumers and introduces a new limit below which power plants are eligible for subsidies under the capacity mechanism. It also imposes an obligation on Member States to prepare contingency plans in the event

of an electricity crisis. The Agency for the Cooperation of Regulators' competencies in cross-border regulatory cooperation are enhanced where there is a risk of national and regional fragmentation.

The fifth energy package, "Ready for 55", was published in 2021 to align the EU's energy targets with the new European climate targets for 2030 and 2050. Following Russia's invasion of Ukraine in February 2022 and after Russia completely cut off gas supplies to Europe, the EU decided to quickly phase out all Russian fossil fuel imports, implement energy-saving measures, diversify energy imports, adopt emergency measures in the electricity and gas markets, and accelerate the introduction of renewable energy sources.

The completion of the EU's internal market in the energy sector requires the removal of a number of obstacles and barriers to trade, the approximation of tax and pricing policies and measures concerning norms and standards, and the introduction of safety and environmental provisions. The aim is to ensure a functioning market with fair access, a high level of consumer protection, and an adequate level of interconnection and generation capacity.

Within the framework of the establishment or functioning of the internal market and taking into account the need to preserve and improve the environment, European Union energy policy shall aim, in a spirit of solidarity between Member States, at:

- ensuring the functioning of the energy market;
- ensuring the security of energy supply in the Union;
- promoting energy efficiency and energy saving, as well as the development of new and renewable forms of energy;
- promoting the interconnection of energy networks (Consolidate version of the treaty on the functioning of the European Union 2016, p. 5).

As announced in the Energy Union Strategy, in 2016, the European Commission presented **the Clean Energy for All Europeans package** to provide consumers with secure, sustainable, competitive, and affordable energy. It supports the decarbonization of the EU's energy sector, removes barriers to cross-border electricity trade, and enables the EU's clean energy transition, meeting the commitments made in the Paris Agreement. The regulation sets out a set of market rules for the functioning of electricity markets: prices will be set on the basis of supply and demand; recipients will take advantage of market opportunities and will be active market participants; incentives for low-carbon electricity generation will be based on market principles; barriers to cross-border electricity flows will be gradually removed; generators will be directly or indirectly responsible for the sale of the electricity they produce; new conditions will be defined under which Member States can establish capacity mechanisms and the rules for their creation.

The Directive on common rules for the internal market in electricity (Directive (EU) 2019/944) focuses on Member States and consumers, setting out a set of different rules that put the consumer at the center of the clean energy transition. Suppliers are free to set the prices at which they deliver electricity to consumers. Consumers may request the installation of smart electricity meters at no additional cost. Household and micro-enterprise customers shall have free access to one or more tools for comparing supplier offers, including dynamic electricity price contract offers.

On 14 March 2023, the European Commission proposed a reform of the electricity market structure, in particular the Electricity Regulation, the Electricity Directive and the REMIT Regulation (EU) No. 1227/2011. The proposal includes measures to incentivize long-term non-fossil energy contracts, industry access to renewables, renewable energy sharing provisions, long-term contracts for consumers, new demand and storage response support schemes, protection of vulnerable consumers in default against disconnection, extension of regulated retail prices to households and SMEs in the event of a crisis, and obligations for Member States to appoint suppliers of last resort. The regulation proposes common rules on electricity crisis prevention and preparedness to ensure cross-border cooperation, as well as common rules on crisis management, common methodologies for assessing the security of supply risks and a common framework for evaluating and monitoring the security of electricity supply.

In response to the escalation of the global energy crisis, the EU has put forward several proposals for profound structural changes in its energy markets. In March 2022, the European Commission Communication on REPowerEU immediately stated that the EU intends to gradually become independent of Russian fossil fuels. In May 2022, the REPowerEU plan was presented, proposing additional measures to save energy, diversify supplies, increase the security of energy supply, and replace fossil fuels by accelerating the deployment of renewable energy. In July 2022, the Commission proposed new rules for coordinated measures to reduce gas demand and published a communication entitled "Saving gas for a safe winter". Council Regulation (EU) 2022/1369 on coordinated measures to reduce gas demand, which entered into force on 9 August, set a voluntary (and in an emergency, mandatory) target to reduce gas consumption in Member States by 15% between 1 August 2022 and 31 March 2023. In September 2022, the Commission proposed a Council Regulation on emergency intervention to address high energy prices and lower energy bills for European citizens and businesses. Between September and December 2022, the Council adopted three exceptional temporary market-based measures: a voluntary general target of a 10% reduction in gross electricity consumption for the period from 1 December 2022 to 31 March 2023 and a mandatory target of 5% reduction in peak electricity consumption; a market revenue ceiling of EUR 180/MWh for electricity generators using renewable energy sources, nuclear energy and lignite; and a mandatory temporary solidarity levy for the fossil fuel sector.

Conclusion

The Green Deal Industrial Plan: putting Europe's net-zero industry in the lead

Trans-European energy networks (TEN-E)

TEN-E is a policy strategy that focuses on interconnecting Member States' energy infrastructure. Under this strategy, 11 priority corridors have been identified (three for electricity, five for offshore grids and three for hydrogen) and three priority thematic areas (the deployment of smart electricity grids, smart gas grids, and a cross-border carbon dioxide network).

The TEN-E Regulation (EU) 2022/869 provides guidelines for trans-European energy networks, identifying projects of common interest of EU countries, projects of common interest for the EU and third countries, and priority projects for trans-European electricity and gas networks. New Energy Projects of Common Interest and cross-border renewable energy projects are funded by the Connecting Europe Facility – Energy (CEF-E) 2021–2027, with a seven-year budget of EUR 5.84 billion distributed through grants managed by the European Climate, Infrastructure and Environment Executive Agency. Between 2014 and 2020, the CEF-E budget of EUR 4.8 billion funded 149 cross-border energy infrastructure actions in 107 projects of common interest along eight priority corridors. The Commission prepares the list of projects of common interest in the form of a delegated act, which enters into force only if the Parliament and the Council do not object within two months of its submission.

The European Green Deal, presented by the European Commission on 11 December 2019, sets the goal of making Europe the first climate-neutral continent by 2050. The European Climate Law enshrines in binding legislation the EU's commitment to climate neutrality and the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels (European Commission 2023).

The Commission's Directorate-General for Climate Action is responsible for the following proposals:

- Increasing the ambition of the EU Emissions Trading System,
- Strengthening the Market Stability Reserve linked to the review of the EU Emissions Trading System,
- Revision of the EU Emission Trading System Directive concerning aviation (European Commission 2021).

The first pillar of the plan is about a simpler regulatory framework. The European Commission has proposed a Net-Zero Industry Act to identify goals for net-zero industrial

capacity and provide a regulatory framework suited for its quick deployment, ensuring simplified and fast-track permitting, promoting European strategic projects, and developing standards to support the scale-up of technologies across the Single Market. The framework will be complemented by the Critical Raw Materials Act to ensure sufficient access to those materials, like rare earths, that are vital for manufacturing key technologies and the reform of the electricity market design (Parlament Europejski n.d.).

The fourth pillar is about global cooperation and making trade work for the green transition under the principles of fair competition and open trade, building on the engagements with the EU's partners and the work of the World Trade Organization. To that end, the Commission will continue to develop the EU's network of Free Trade Agreements and other forms of cooperation with partners to support the green transition. It will also explore the creation of both a Critical Raw Materials Club, to bring together raw material 'consumers' and resource-rich countries to ensure global security of supply through a competitive and diversified industrial base, and Clean Tech/Net-Zero Industrial Partnerships (European Commission 2023).

The *Fifth Energy Package*, entitled *'Fit For 55'*, was published in two parts on 14 July and 15 December 2021 and is currently in the final approval phase. It brings energy targets into line with the new European climate ambition of reducing emissions by at least 55% by 2030 compared to 1990 levels and becoming carbon neutral by 2050. It focuses mainly on renewables, energy efficiency, energy taxation, buildings, air and maritime transport, buildings, gas and hydrogen markets. The Russian invasion of Ukraine of 24 February 2022 produced major market disruptions, forcing the EU to change its regulatory framework for energy. Among the measures taken that affect the market, in 2022, the Commission proposed:

- Options to mitigate high energy prices,
- The creation of a platform for joint purchases of gas,
- New gas storage rules and obligations,
- The easing of liquidity measures for energy market players,
- Electricity and gas demand reduction measures,
- Gas solidarity measures among Member States,
- New price benchmarks for LNG,
- Measures for redistributing the energy sector's surplus revenues to final customers,
- A safety price ceiling (European Union n.d.).

Tables and Figures

Table 1. Carbon dioxide emissions in European Union countries, 2012–2021 (in million tonnes)

Country/year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
*European Union**	*2,712.2*	*2,614.8*	*2,508.7*	*2,556.6*	*2,552.0*	*2,595.4*	*2,551.1*	*2,416.4*	*2,117.9*	*2,246.2*
Belgium	73.3	71.2	68.8	71.7	71.2	71.2	72.6	73.3	66.4	68.3
Bulgaria	47.1	41.7	44.5	47.1	44.5	46.7	42.5	41.1	35.5	40.7
Czechia	89.5	85.5	84.6	83.5	85.7	84.0	85.3	80.1	71.7	77.0
Denmark	71.2	70.0	64.1	64.4	67.2	67.4	69.9	66.8	57.2	52.2
Germany	694.5	703.3	660.6	670.0	666.8	657.3	637.3	576.6	497.1	533.5
Estonia	17.8	19.9	18.7	15.2	16.8	18.2	17.3	11.6	8.7	10.1
Ireland	34.0	33.6	34.2	36.0	40.0	42.0	42.6	41.6	29.0	31.8
Greece	84.2	76.7	74.0	70.3	68.4	73.7	73.4	68.0	57.5	59.0
Spain	222.8	195.8	198.8	214.5	202.0	217.8	212.1	194.5	159.3	168.7
France	253.4	253.7	232.7	234.6	235.6	239.5	230.7	226.9	196.2	212.1
Croatia	14.1	13.8	13.1	13.0	13.1	13.7	12.7	12.9	12.2	11.7
Italy	303.7	270.7	254.8	262.5	260.1	262.1	256.0	249.6	219.4	239.7
Cyprus	5.7	5.1	5.4	5.2	5.6	5.9	5.9	5.6	5.4	5.4
Latvia	7.3	7.0	6.8	7.0	6.9	7.0	7.6	7.7	6.2	6.4
Lithuania	12.3	11.3	12.0	12.6	12.3	13.2	14.3	14.7	16.2	16.7
Luxembourg	6.7	6.6	6.8	7.6	7.5	7.5	7.6	8.2	7.3	7.7
Hungary	37.2	35.5	35.9	37.8	37.5	39.5	39.8	38.5	35.5	35.8
Malta	2.7	2.4	2.4	1.7	1.4	1.5	1.6	1.7	1.5	1.5
Netherlands	149.5	148.6	148.7	154.0	153.1	150.7	147.0	143.9	126.4	127.2
Austria	48.1	46.8	44.4	45.5	44.7	47.7	45.8	49.1	43.5	46.5
Poland	282.0	278.9	270.3	272.8	281.0	293.6	294.6	283.3	269.5	291.9
Portugal	44.3	42.6	42.4	46.7	44.4	49.3	45.9	42.1	36.0	34.4
Romania	80.7	67.2	66.4	65.5	64.3	66.6	68.0	64.8	61.8	64.7
Slovenia	11.4	11.2	9.8	10.0	10.4	10.6	10.9	10.8	10.4	10.0
Slovakia	30.4	28.3	26.5	27.7	28.2	29.1	29.5	27.3	24.7	28.5
Finland	48.3	49.1	44.9	41.6	44.9	42.2	43.6	40.9	33.8	34.0
Sweden	39.8	38.6	37.0	37.9	38.4	37.4	36.4	34.7	29.8	30.7

* 27 countries (from 2020), (e) estimated, (s) Eurostat estimate
Source: own elaboration based on Eurostat (2023).

Table 2. Carbon dioxide emissions in European Union countries in 2012 and 2021 (in thousand tonnes) and their growth (in %)

Country/year	2012	2021	Growth (%)
Belgium	73,292.2	68,313.7	– 6.8
Bulgaria	47,139.1	40,728.8	– 13.6
Czechia	89,526.6	76,988.2	– 14.0
Denmark	71,209.7	52,215.5	– 26.7
Germany	694,542.2	533,461.5	– 23.2
Estonia	17,783.5	10,080.1	– 43.3
Ireland	33,979.5	31,792.3	– 6.4
Greece	84,214.8	58,982.0	– 30.0
Spain	222,785.9	168,656.6	– 24.3
France	253,422.3	212,106.5	– 16.3
Croatia	14,145.7	11,743.6	– 17.0
Italy	303,729.4	239,652.9	– 21.1
Cyprus	5,712.9	5,421.7	– 5.1
Latvia	7,306.6	6,435.9	– 11.9
Lithuania	12,263.7	16,670.4	35.9
Luxembourg	6,738.7	7,654.9	13.6
Hungary	37,160.9	35,791.8	– 3.7
Malta	2,744.7	1,485.5	– 45.9
Netherlands	149,516.3	127,215.8	– 14.9
Austria	48,148.9	46,488.6	– 3.4
Poland	282,013.4	291,917.1	3.5
Portugal	44,290.8	34,416.1	– 22.3
Romania	80,716.1	64,741.2	– 19.8
Slovenia	11,357.3	10,015.9	– 11.8
Slovakia	30,415.1	28,478.6	– 6.4
Finland	48,262.0	34,036.1	– 29.5
Sweden	39,814.2	30,737.4	– 22.8

(e) estimated, (s) Eurostat estimate
Source: own elaboration based on Eurostat (2023).

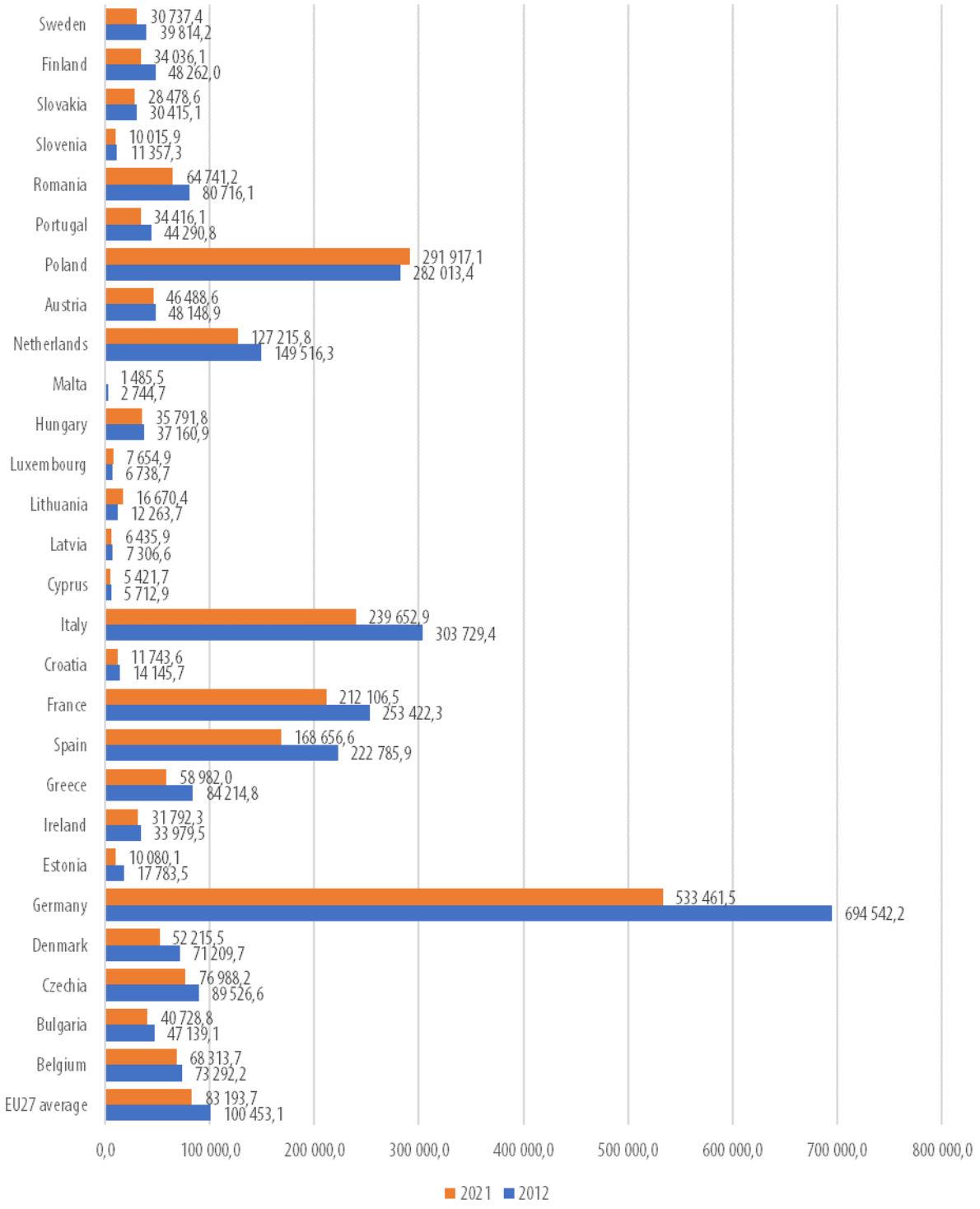

Figure 1. Carbon dioxide emissions in European Union countries and EU average in 2012 and 2021 (in thousand tonnes)

Source: own elaboration based on Eurostat (2023).

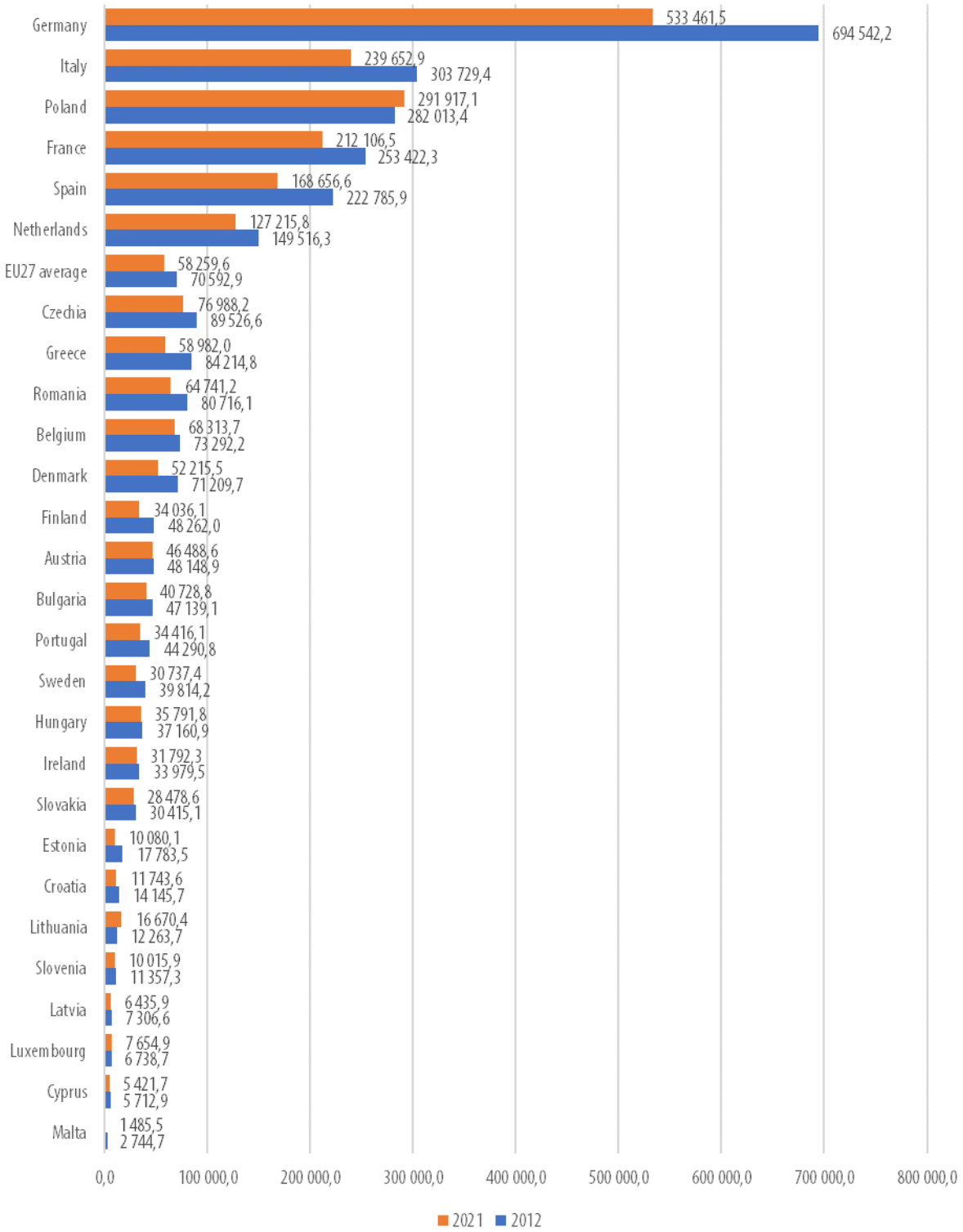

Figure 2. Carbon dioxide emissions in European Union countries and EU average 2012 and 2021 (in tonnes)

Source: own elaboration based on Eurostat (2023).

Table 3. Electricity prices for household and non-household consumers – bi-annual data for 2021 and 2022 (in euros per 100 kilowatt-hours)

Country/time	Household consumers per 100 kilowatt-hours		Non-household consumers per 100 kilowatt-hours		Household consumers Increase 2021-S2–2022-S2	Non-household consumers Increase 2021-S2–2022-S2
	2021-S2	2022-S2	2021-S2	2022-S2		
European Union*	–	27.94	–	25.34		
Belgium	30.02	45.19	16.43	28.17	**+15.17**	**+11.74**
Bulgaria	10.91	11.49	17.6	20.64	**+0.58**	**+3.04**
Czechia	18.71	39.20	12.53	23.85	**+20.49**	**+11.32**
Denmark	28.73	53.70	31.16	43.65	**+24.97**	**+12.49**
Germany	32.88	34.75	20.97	25.80	**+1.87**	**+4.83**
Estonia	19.6	23.81	16.75	28.21	**+4.21**	**+11.46**
Ireland	27.99	–	20.72	30.61	–	**+9.89**
Greece	20.86	25.91	17.62	23.64	**+4.95**	**+6.2**
Spain	28.78	34.52	17.30	27.72	**+5.74**	**+10.42**
France	19.7	21.06	12.59	14.95	**1.36**	**+2.36**
Croatia	13.25	14.93	13.04	27.44	**+1.68**	**+14.40**
Italy	26.13	39.23	21.70	39.07	**+13.10**	**+17.37**
Cyprus	23.17	33.63	22.76	37.03	**+10.46**	**+14.27**
Latvia	19.61	–	–	–		–
Lithuania	15.01	24.74	15.91	32.57	**+9.73**	**+16.66**
Luxembourg	19.01	19.45	11.28	19.20	**+0.44**	**+7.92**
Hungary	10.12	10.92	13.62	32.41	**+0.80**	**+18.79**
Malta	15.81	14.94	–	–	**– 0.87**	–
Netherlands	13.73	9.75	14.69	21.41	**+3.98**	**+6.72**
Austria	22.52	23.56	15.44	23.86	**+1.04**	**+8.42**
Poland	16.54	17.09	13.87	19.69	**+0.55**	**+5.82**
Portugal	22.85	23.47	16.86	18.12	**+0.62**	**+1.26**
Romania	16.11	34.21	15.09	36.55	**+18.10**	**+21.46**
Slovenia	16.38	18.86	12.65	21.88	**+2.48**	**+9.23**
Slovakia	16.29	18.91	17.20	30.51	**+2.62**	**+13.39**
Finland	16.05	19.78	10.35	16.63	**+3.73**	**+6.28**
Sweden	20.53	22.27	11.86	17.95	**+1.74**	**+6.09**

* 27 countries (from 2020), (–) not available, 2021-S2 – second half of 2021, 2022-S2 – second half of 2022
Source: own elaboration based on Eurostat (2024a).

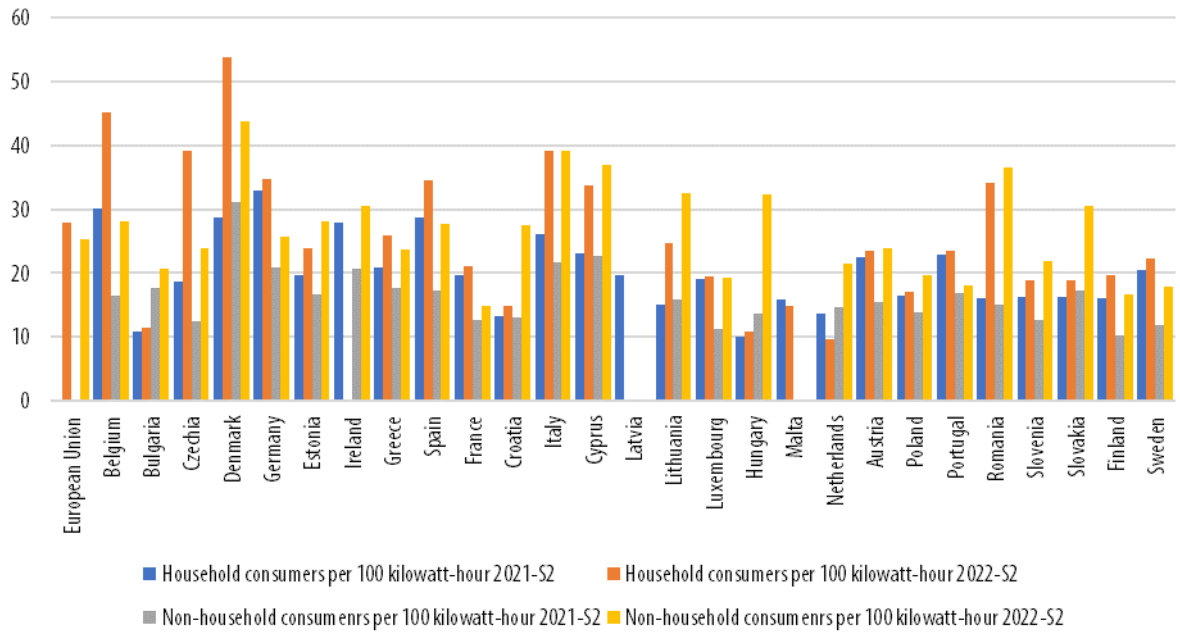

Figure 3. Electricity prices for household and non-household consumers – bi-annual data for 2021 and 2022 (in euros per 100 kilowatt-hours), 2021-S2 – second half of 2021, 2022-S2 – second half of 2022

Source: own elaboration based on Eurostat (2024a).

Table 4. Gross electricity production (in million tonnes of oil equivalent)

Country/year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
*European Union**	***252.3***	*250.8*	*245.6*	*249.4*	*251.2*	*254.0*	*252.6*	*249.6*	*239.5*	***249.9***
Belgium	**7.1**	7.1	6.2	6.0	7.3	7.4	6.4	8.0	7.6	**8.6**
Bulgaria	**4.1**	3.8	4.1	4.2	3.9	3.9	4.0	3.8	3.5	**4.1**
Czechia	**7.5**	7.5	7.4	7.2	7.2	7.5	7.6	7.5	7.0	**7.3**
Denmark	**2.6**	3.0	2.8	2.5	2.6	2.7	2.6	2.5	2.5	**2.8**
Germany	**53.9**	54.8	53.8	55.6	55.8	56.1	54.9	52.1	49.3	**50.4**
Estonia	**1.0**	1.1	1.1	0.9	1.0	1.1	1.1	0.7	0.5	**0.6**
Ireland	**2.4**	2.2	2.2	2.4	2.6	2.7	2.7	2.7	2.8	**2.7**
Greece	**5.2**	4.9	4.3	4.5	4.7	4.8	4.6	4.2	4.1	**4.7**
Spain	**25.6**	24.6	24.0	24.1	23.6	23.7	23.6	23.5	22.6	**23.6**
France	**49.2**	50.0	49.2	49.8	48.5	48.3	50.0	49.0	45.7	**47.7**
Croatia	**0.9**	1.2	1.2	1.0	1.1	1.0	1.2	1.1	1.2	**1.3**
Italy	**25.7**	24.9	24.0	24.3	24.9	25.4	24.9	25.2	24.1	**24.8**
Cyprus	**0.4**	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	**0.4**
Latvia	**0.5**	0.5	0.4	0.5	0.6	0.6	0.6	0.6	0.5	**0.5**

Country/year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Lithuania	**0.4**	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.5	**0.4**
Luxembourg	**0.3**	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	**0.2**
Hungary	**3.0**	2.6	2.5	2.6	2.7	2.8	2.7	2.9	3.0	**3.1**
Malta	**0.2**	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	**0.2**
Netherlands	**8.9**	8.7	8.9	9.4	9.8	9.9	9.8	10.4	10.6	**10.5**
Austria	**6.2**	5.9	5.6	5.6	5.9	6.1	5.9	6.4	6.2	**6.1**
Poland	**13.9**	14.1	13.7	14.2	14.3	14.7	14.6	14.1	13.6	**15.4**
Portugal	**4.0**	4.4	4.5	4.5	5.2	5.1	5.1	4.6	4.6	**4.4**
Romania	**5.1**	5.1	5.6	5.7	5.6	5.5	5.6	5.1	4.8	**5.1**
Slovenia	**1.4**	1.4	1.5	1.3	1.4	1.4	1.4	1.4	1.5	**1.4**
Slovakia	**2.5**	2.5	2.3	2.3	2.3	2.4	2.3	2.4	2.5	**2.6**
Finland	**6.0**	6.1	5.8	5.9	5.9	5.8	6.0	5.9	5.9	**6.2**
Sweden	**14.3**	13.2	13.2	13.9	13.4	14.1	14.0	14.5	14.1	**14.8**

* 27 countries (from 2020)
Source: own elaboration based on Eurostat (2024b).

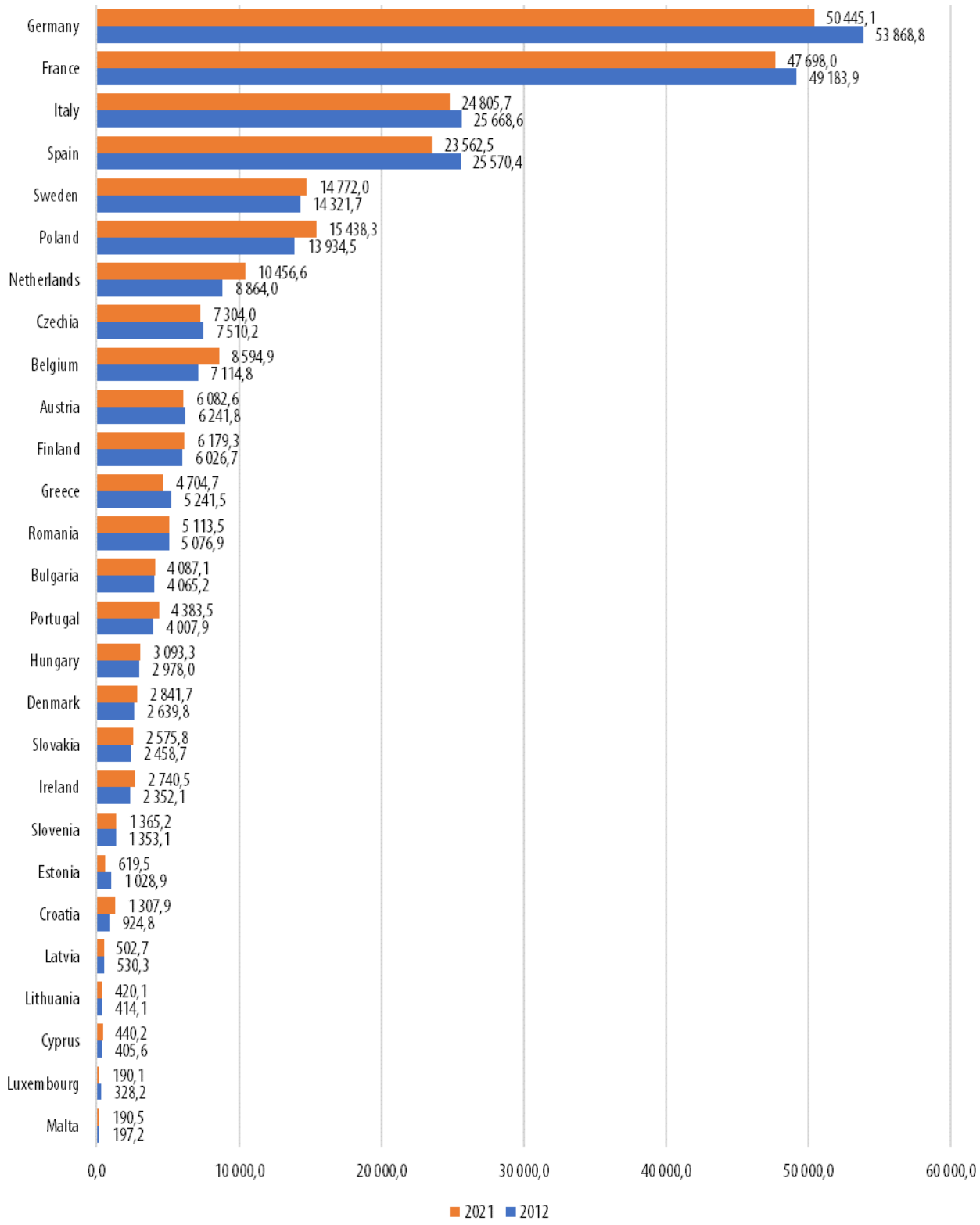

Figure 4. Gross electricity production in 2012 and 2021 (in thousand tonnes of oil equivalent)

Source: own elaboration based on Eurostat (2024b).

Table 5. Gross electricity production in 2012 and 2021 (in thousand tonnes of oil equivalent)

Country/year	2012	2021
Belgium	**7,114.8**	**8,594.9**
Bulgaria	4,065.2	4,087.1
Czechia	7,510.2	7,304.0
Denmark	2,639.8	2,841.7
Germany	**53,868.8**	**50,445.1**
Estonia	1,028.9	619.5
Ireland	2,352.1	2,740.5
Greece	5,241.5	4,704.7
Spain	**25,570.4**	**23,562.5**
France	**49,183.9**	**47,698.0**
Croatia	924.8	1,307.9
Italy	**25,668.6**	**24,805.7**
Cyprus	405.6	440.2
Latvia	530.3	502.7
Lithuania	414.1	420.1
Luxembourg	328.2	190.1
Hungary	2,978.0	3,093.3
Malta	197.2	190.5
Netherlands	**8,864.0**	**10,456.6**
Austria	6,241.8	6,082.6
Poland	**13,934.5**	**15,438.3**
Portugal	4,007.9	4,383.5
Romania	5,076.9	5,113.5
Slovenia	1,353.1	1,365.2
Slovakia	2,458.7	2,575.8
Finland	**6,026.7**	**6,179.3**
Sweden	**14,321.7**	**14,772.0**

Source: own elaboration based on Eurostat (2024b).

Conclusions from tables and figures

Table 1 and Figure 1 present carbon dioxide emissions in European Union countries, 2012–2021 (in million tonnes).

Between 2012 and 2021, the European Union reduced carbon dioxide emissions into the atmosphere from 2,712.2 to 2,246.2 million tonnes. Decreases were recorded in all EU countries except Lithuania, Luxembourg and Poland.

Table 2. Carbon dioxide emissions in European Union countries in 2012 and 2021 (in thousand tonnes) and its growth (in %).

A comparison of carbon dioxide emissions in European Union countries in 2012 and 2021 (in thousand tonnes) and their growth (in %) shows that only Poland recorded an increase, while particularly large decreases in emissions took place in Greece, Italy, Lithuania, Malta, Portugal, Finland and Sweden.

Table 3. Electricity prices for household and non-household consumers – bi-annual data for 2021 and 2022 (in euros per 100 kilowatt-hours).

Table 3 (and Figure 3) show that concerning household consumers, the semi-annual data for 2021–2022 indicate that the most significant price increases were recorded in Denmark (+24.97), the Czech Republic (+20.49), Romania (+18.10) and Italy (+18.10) (+13.10), while a decline in price growth was recorded only in Malta (–0.87). As regards non-household consumers, the relevant semi-annual data for 2021–2022 indicate that the highest price increases were recorded in Romania (21.46), Hungary (+18.79), Italy (17.37), Croatia (+14.40), Cyprus (+14.27), Denmark (+12.49), Belgium (+11.74), Estonia (+11.46), Czech Republic (11.32), Spain (++10.42).

Table 4. Gross electricity production (in million tonnes of oil equivalent).

Table 4 presents the value of electricity production in the European Union and its member states between 2012 and 2021. It shows that in the analyzed years, there was a decrease in production in the EU from 252.3 to 249.9 million tonnes. In contrast, production increased in Belgium, Ireland, Croatia, Poland, Portugal, Slovakia, Finland, Sweden and Hungary.

Table 5 shows EU countries with a high increase in electricity production between 2012 and 2021. They include Poland, the Netherlands, Sweden, Belgium and Finland. Meanwhile, Germany, Spain, France and Italy recorded a decrease.

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Polityka energetyczna w Unii Europejskiej w ramach strategii Europejskiego Zielonego Ładu

Celem artykułu jest przedstawienie polityki energetycznej Unii Europejskiej w świetle jej najnowszej strategii Europejski Zielony Ład. W artykule szczególne znaczenie ma udzielenie odpowiedzi na dwa główne pytania.

Pierwsze pytanie brzmiało: „Jakie znaczenie w polityce energetycznej UE miały dwa pakiety energetyczne, tzn. czwarty i piąty pakiet?". Czwarty pakiet został przyjęty w czerwcu 2019 r. a pakiet piąty – „*Ready for 55*" został opublikowany w roku 2021. Piąty pakiet energetyczny miał dostosować cele energetyczne UE do nowych europejskich celów klimatycznych na lata 2030 i 2050.

Drugie pytanie dotyczyło tego, jakie są główne wnioski z przedstawionych tabel i wykresów, dotyczące zarówno emisji dwutlenku węgla w krajach Unii Europejskiej w latach 2012–2021, jak i zmian cen energii elektrycznej dla gospodarstw domowych i odbiorców niebędących gospodarstwami domowymi w euro za 100 kilowatogodzin. Zaprezentowana została również wartość produkcji energii elektrycznej brutto (w mln ton ekwiwalentu ropy naftowej) w analizowanych latach dla wszystkich krajów członkowskich UE.

Słowa kluczowe: Unia Europejska, polityka energetyczna, pakiety energetyczne, kraje UE, wartości zużycia energii przez gospodarstwa domowe i niebędących gospodarstwami domowymi odbiorców energii

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.14

The Concept of Structural Equation Modelling for Measuring the Shadow Economy – International and Polish Perspectives

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Abstract

The goal of the article is to explore the potential of explicatory Structural Equation Modelling (SEM) and its specifications for measuring the shadow economy (SE). This is done from the perspective of various approaches in selected countries.
The article is a review and conceptual paper. The study is divided into three stages: a comprehensive description of the nature of the SE and the difficulties associated with measuring

Received: 9.06.2023. Verified: 18.10.2023. Accepted: 2.04.2024

it; a comparative analysis of the approaches applied in selected EU countries (with particular emphasis on Italy and Poland), and finally, the concept of SE estimation based on SEM model is proposed.
One of the most important limitations regarding the SE is that it is not possible to measure the extent of this phenomenon directly. This leads to the use of non-standard estimation techniques based on latent variable models. The innovation of this approach is that it considers three factors that are not directly observable, i.e., tax morality, concealing salaries, and regulation of the economy.
The proposed model allows us to capture and explain empirical SE phenomena more precisely and effectively than with classical statistical and econometric methods. However, we are aware that it is highly probable that many SEMs will need to be tested and modified to achieve the final result.

Keywords: shadow economy, national statistical offices, structural equation models, unobserved variables, international economy

JEL: A10, B41, C01, C18, C51

Introduction. The shadow economy as a research challenge

The shadow economy (SE) is an important and contemporary research problem, both for individual experts involved in the analysis, assessment, and measurement of the economy, as well as for state authorities whose task is to counteract this phenomenon. Although the SE has always existed in all economies, regardless of their level of development or geographical context, it is still an area where methodological disagreement persists in terms of measurement. The basis for this dispute can be seen from the very beginning of the research process, i.e., at the stage of agreeing on a definition.

In the literature, the SE is also referred to as grey, informal, hidden, secondary, mysterious, concealed, parallel, black, dual, or under-the-table (cf. Orsi, Davide, and Turino 2014; Buehn and Schneider 2016; Medina and Schneider 2018; Piecuch and Szczygieł 2018). Attempts to define this phenomenon are made not only by economists, lawyers, and sociologists but also by psychologists, philosophers, those who work in management sciences, and ethics specialists.

The SE is an ambiguous and widespread phenomenon, and it is a major challenge for researchers around the world, among whom there is a consensus on the need to measure it. When analysing the methods of estimating the size of the SE, a literature review indicates a multitude of methods (e.g. Buehn and Schneider 2016; Dymarski 2016). In principle, two groups can be distinguished: direct and indirect. In the first group, Mróz (2002) lists household surveys, tax surveys, labour market surveys, and direct surveys of partial markets. In contrast, intermediate methods, which use the traces that the SE leaves in different sizes and economic indicators, include the analysis of discrepancies between expenditure and income statistics,

microeconomic analyses of the labour market, monetary methods, econometric methods, methods based on the consumption balances of certain materials and raw materials, multivariate methods, indirect analytical partial methods, and Delphic methods (Mróz 2002). Each of them has its advantages and disadvantages.

An unquestionable advantage of direct methods is that information can be obtained directly from business owners using, for example, direct interviews, which ensures the desired level of information detail. However, this type of research raises the question of data quality. This is because there is a subjective nature to the information provided by those involved in the SE. In addition, direct methods, however detailed, are most often fragmented, and thus relate to selected areas of the economy, without meeting the condition of representativeness for the whole economy. Mróz (2002) points this out by indicating the problematic and dangerous moment of transition from estimating specific spheres of the SE to assessing its global size.

On the other hand, indirect methods, especially econometric methods, enable the construction of multivariate models that can describe the entire economy. They are easier to use because there is no need to perform primary research. They are also more transparent and make it easier to follow the dynamics of the phenomenon over longer time horizons. Mróz (2002) lists formal elegance among the advantages of econometric methods. At the same time, he draws attention to the risks arising from subjectivity and even arbitrariness in the selection of indicators and assumptions. In the discussion on the advantages and disadvantages of different methods of measuring SE, researchers agree in principle that when studying a phenomenon that is not subject to traditional statistical observation, several complementary research methods should be used simultaneously (Szewczyk-Jarocka 2011).

The article presents the idea of a methodology developed in the area of econometric methods based on the technique of structural equation models with latent variables. The aim is to present the unused potential of an explicative *Structural Equation Modelling* (SEM) and its specifications in the context of measuring the SE from international and Polish perspectives. This article serves as a conceptual review and contribution to the international discussion on improving SE estimations.

The shadow economy as a research problem for national statistical offices – an international overview

The size of the SE in public European statistics is estimated in the system of national accounts, which, within the framework of the European System of National Accounts[1] in force in EU countries, should aim at the completeness of GDP and GNI estimates. This means that, in addition to directly observed production (through statistical surveys or administrative data), they should include the SE as one of the elements of the non-observed economy (NOE). To unify the practices of individual countries, which would improve the completeness of national accounts, Eurostat has defined a universal seven-part scheme categorising data incompleteness (Table 1). The scheme is based on the division of producers (data providers) into four types, depending on the accuracy deficiencies that individual groups of producers may generate. Each type of producer is assigned different types of incompleteness (N1–N7).

Table 1. Types of incomplete data in the European System of National Accounts

Type of producers	Symbol	Name	Characteristic description
Unregistered	N1	Producers deliberately not registering – underground	Entrepreneurs want to avoid taxes and social security contributions. Type N1 does not cover all hidden activities, some of which are type N6.
	N2	Producers deliberately not registering – illegal	Entrepreneurs involved in illegal production. Type N2 does not include illegal activities conducted by legal entities or business owners who are engaged entirely or partially in illegal activities within a legally registered company.
	N3	Producers are not required to register	Business owners who do not have to register because they do not produce for the market. Usually, they are households producing for their private use, which undertake the production of goods for their consumption or their own fixed assets, construction, and renovations of dwellings. This group also includes business owners with a market production so small that there is no obligation to register it.

1 The European System of National and Regional Accounts in the European Union, implemented in the Polish system of official statistics in accordance with Regulation (EU) No. 549/2013 of the European Parliament and of the Council of May 21, 2013.

Type of producers	Symbol	Name	Characteristic description
Not surveyed	N4	Legal persons not surveyed	Legal persons not surveyed for various reasons, e.g. outdated registers, incorrect data classifying the type of activity, size of the company, etc. This leads to a systematic error in the exclusion of legal persons from the research in which they should be involved.
	N5	Registered business owners not surveyed	Registered enterprises not surveyed for various reasons, e.g. the statistics do not survey such enterprises, the incompleteness of reports for research, or incorrect classification data (type of activity, size, or territorial classification).
Subtracting Data	N6	Producers deliberately misreporting	Business owners who want to avoid taxes (income, VAT, other taxes) or social security contributions that understate production and/or overstate costs. Data distortion is often accompanied by double-entry accounting, 'envelope' salary payments, cash payments without a bill, and tax evasion (VAT fraud).
Others	N7	Other statistical deficiencies	Incomplete, not collected, or not directly collectable data; data entered, processed, or aggregated incorrectly by statisticians. Among others, the following areas should be included in this type: how to deal with no responses, production of market-producing entities for own use, tips, and salaries in kind.

Source: own compilation based on OECD (2002).

NOE size estimates, in particular of the SE, continue to be a challenge for statistical services in many countries. Despite the practices recommended by Eurostat, such as the use of the incompleteness scheme (N1–N7), periodic international revisions of national accounts are also conducted, including reviews of the completeness of GDP calculations. This process aims to improve the methodologies used by individual countries and ensure the correctness of determining GDP. For example, the revision conducted in 2005/2006 by the United Nations Economic Commission for Europe covered 43 countries: 18 member states of the then EU, five OECD member states outside the then EU, three candidate countries of the then EU, 12 countries of the then Commonwealth of Independent States, and five others. The general conclusions of this review regarding NOE were as follows:

- 34 countries revised their GDP estimates for underreporting (N6);
- 34 countries included the impact of deliberately unregistered units in their GDP estimates (N1);
- 32 countries revised their GDP estimates for units not requiring registration (N3);
- 7 countries included illegal activities in their GDP estimates (N2).

This review focused on the analysis of the following aspects of NOE estimates in the countries studied: data sources, estimation techniques, and presentation. In terms of data

sources, almost all reviewed countries used data from general censuses (population, housing, and agriculture), enterprise research, household surveys, labour market research, tax and treasury databases, police services databases, social services databases, and foreign trade statistics. An overview of the data sources used in selected countries to estimate SE is presented in Table 2.

Table 2. Data sources used in selected countries to estimate SE

Country	Data sources
Belgium	Administrative records (company financial statements, VAT refund data, social security data)
Finland	Data from corporate tax records and tax audits, labour market data (Labour Force Survey)
Germany	Census data, household consumption data, agricultural survey data
The Netherlands	Labour Force Survey, Data from Business Registers, Data from the Social Security Register, Employment Data from Structured Surveys

Source: own compilation based on Urząd Statystyczny w Kielcach (2011).

The review of national practices in selected EU countries showed different approaches to estimating NOE and its components, and how it is published. Some countries published aggregate estimates for NOE (Austria and Finland), others published estimates only for the SE (Belgium, the Netherlands, and the Czech Republic), and still others published estimates for both NOE and the SE (Hungary, Latvia, Poland). Some countries, in turn, showed estimates of selected elements, e.g. extra estimates for avoiding VAT.

The diversity of approaches to estimating the SE means that one should be careful when comparing results between individual countries or even data from one country but at different times or provided by different researchers. Therefore, a decrease or increase in the share of NOE in GDP can mean changes in the scope of economic activities, although it may also be due to improved methods, the use of new statistical data sources, or both.

Estimation of the shadow economy – example of Italy[2] and Poland

As indicated earlier, EU member states use different methodologies to estimate the SE. This is not only due to differences in socioeconomic development but also different structures of national statistics systems (data sources). However, equally important are

2 The example was described on the basis of Urząd Statystyczny w Kielcach (2011, pp. 60–69).

the legal conditions (for example, prostitution, which is included in SE estimates, as it is legal in some countries but not in others), and even cultural differences (for example, the issue of tips for doctors – in Hungarian public statistics, a model was developed to estimate donations in the health service due to the universality of this phenomenon).

In this part of the article, we present the basic principles of the workload method developed by the Italian Statistical Office (ISTAT) and the Statistics Poland approach in this field. The ISTAT method was developed in the 1980s. However, since then, it has been revised several times and, under the recommendations of the European Commission, successively expanded to include further NOE elements. Its principles became the basis for methods developed in other EU countries, including Poland.

In Italy, it is assumed that part of the SE results from economic reasons, i.e. undeclared work, understating legal production, and overstating indirect costs by enterprises. The second reason for the SE is statistics, which is mainly related to the insufficient updating of registers of a large number of small enterprises and the growing group of part-time employees and other producers who are difficult to reach in surveys. To estimate the size of the grey economy, the following are used in Italy:

1) research on unregistered work,
2) adjustments to underestimated income (mainly small enterprises) resulting from adjustments to production per capita and value added,
3) consistency check of aggregated data through supply and use tables at the industry level.

The first two methods are identified with the labour input method mentioned in the introduction. The most important elements include the following:

1. Estimates of labour supply for selected industries and enterprise size classes are obtained based on the Labour Force Survey and other demographic studies.
2. Estimates of output per unit of labour input or value added per unit of labour input for similar industries and enterprise size classes are obtained from regular surveys or special surveys.
3. Estimates of production and value added by industry and enterprise size are obtained using appropriate coefficients related to unit estimates.

The adopted method minimises problems related to identifying enterprises that conduct economic activity and structural changes, which are the main cause of the statistical SE (thus reassigning this area to the observed economy).

As mentioned, an important element of the Italian approach to estimating the size of the SE, and more broadly, the unobserved economy, is estimating the total labour input. It involves calculating the equivalent of legal work (defined as registered in the relevant offices) in terms of full-time, illegal (unregistered) work of residents and the registered and unregistered work of non-residents. Estimates are made while comparing, harmonising, and integrating data from the above-mentioned sources. At the same time, the results on the demand and supply sides are compared.

In Poland, to ensure the quality of national statistics resulting from the European Statistics Code of Practice[3], research conducted in the area of national accounts ensures coherence of the statistical information system from the point of view of definitions of concepts, classifications, and estimation methods. It thus provides a basis for conducting reliable socio-economic statistical analyses in the country and the European Union. According to Eurostat's guidelines, surveys of Polish public statistics assume that the SE includes production activities in the economic sense that are completely legal (in terms of meeting standards and egulations) but which are hidden from public authorities to avoid paying income tax, value-added tax, and other taxes and social security contributions; to avoid the application of legal requirements such as minimum wages, maximum working hours, and work safety conditions; to avoid administrative procedures such as completing statistical questionnaires and other forms. It corresponds to type N6 in Eurostat's notation of incomplete data types (Table 1).

In estimating the size of the SE, Statistics Poland uses a direct method, i.e., an annual representative survey addressed to small entities, and indirect methods. The indirect methods include surveying undeclared work through a survey of the population's economic activity and a modular survey of undeclared work, a consumer questionnaire survey, estimates of activities related to providing sexual services, and the smuggling of cigarettes legally produced in Poland. Official estimates of the SE are made for registered small private-sector businesses in the scope of understated production and revenue in the information provided for statistics and VAT fraud and natural persons for performing undeclared work, mainly in the services sector. The direct method is used to estimate hidden production in registered business entities. It comprises estimating norms of average labour productivity and average remuneration per employee. These norms are then used to estimate average income per employee, which in turn is the basis for estimating global production, intermediate consumption, and gross value added (GUS 2022, p. 110).

As mentioned above, SE size estimates in Poland, prepared by public statistics services, are based on a direct survey of small enterprises and indirect methods of surveying

3 The European Statistics Code of Practice adopted by the European Statistical System Committee on 28.09.2011. The principles of the Statistics Code of Practice together with the general principles of quality management constitute a common quality framework for the European Statistical System.

undeclared work, as well as consumer surveys. In search of possibilities of using alternative measurement methods, especially in the field of econometric methods, the Statistical Office in Kielce[4] has tried to specify estimation techniques based on the idea of SEM for hidden variables.

To the best of our knowledge, only a special case of general SEM has been used in research to estimate the size of the SE, namely the MIMIC (Multiple Indicators Multiple Causes) rule, allowing the relatively simple identification of a class of models. The MIMIC model was first used to estimate the SE by Frey and Weck-Hanneman (1984) in 17 OECD countries. In 1988, Aigner, Schneider, and Ghosh proposed an extended form of the MIMIC model by adding a time factor, the dynamic MIMIC model, the DYMIMIC, which they used to model the SE for the USA. In subsequent years, Giles (1995; 1999) and Giles and Tedds (2002) estimated the size of the SE for New Zealand, Canada, Australia, and other countries of the Pacific. In 2003, Dell'Anno and Schneider (2005) estimated the SE for Italy compared to other OECD countries. In 2007, Dell'Anno, Gomez-Antonio, and Pardo estimated the size of the SE in Mediterranean countries, i.e., France, Spain, and Greece. Buehn and Schneider (2008) used the MIMIC model to estimate the SE in France, while Zagoršek, Jaklič, and Hribernik (2009) presented an analysis of informal activities in Slovenia. They pointed out institution that, in their opinion, were closely related to the development and functioning of the SE. The most recent research in this field was by Efendic, Pasovic, and Efendic (2018), who presented the results of a study on the size dynamics of the SE in Bosnia and Herzegovina from 1998 to 2016. The MIMIC model and its modification were also presented by Dybka et al. (2017), who estimated the SE for 43 countries.

Models of structural equations

In the literature on the subject, models of structural equations are often included among models described as influential statistical revolutions in social sciences (e.g. Cliff 1983; Staniec 2018). SEM is a multivariate technique, or rather a set of statistical procedures and tools that make it possible to describe direct and indirect connections between observable variables (explicit, measurable) and variables that are not directly observable (hypothetical constructs, latent/hidden variables).

In general, SEM can be understood as the combination of factoranalysis and multiple regression analysis, where latent variables or factors are an underlying cause of multiple observed (measured) variables. Consequently, in the simplest terms, SEM can be understood as a path analysis model in which latent variables are allowed (Kline 2011).

4 In Statistics Poland, the Statistical Office in Kielce is responsible for estimating the SE.

The SEM approach is a highly flexible and comprehensive methodology that differs from traditional approaches in several areas, as described below.

While traditional methods only account for measured variables, SEM incorporates observed and unobserved variables (latent constructs). The use of unobserved variables allows us to specify measurement error (to recognise the imperfect nature of the observations), while traditional techniques assume that measurement is free of error. The analytical part of the model allows for measurement errors, while the structural part determines the prediction error of the model. The idea of the approach is to recreate the structure of the substantive process of the variables studied using a simplified theoretical structure of covariance (or correlation) of observable variables. Although the original idea of SEM was based on linear statistical models, modifications can be introduced that allow the inclusion of nonlinear causal relationships, correlated random components, and latent variables. SEM resolves problems of multicollinearity (a common problem when estimating linear or generalised linear models). Multicollinearity cannot occur because unobserved variables represent different latent constructs. This is important for measuring the SE because traditional techniques only analyse measurable variables. Another noteworthy difference is that the traditional approach specifies the default form of the model, while the structural approach requires a formal specification supported by theory and/or research (the axiomatisation of theory). In this case, speaking about the model means a model that fits the theory, i.e. a model whose structure reconstructs the theory. The specification of SEM (making hypotheses) requires the researcher to have an excellent knowledge of theories and research or excellent intuition and to determine a priori the relationships between the variables. Otherwise, the estimated models, despite the high values of the data-fitting indicators, may have little to do with the described and analysed reality. The advantages of this technique are complemented by a graphical way of presenting a hypothetical structure of connections between variables, which presents a complex structure of a phenomenon in a simple way using a path chart/diagram.

However, the versatility of the method, which is undoubtedly an advantage, may lead to serious difficulties and consequently undermine the validity of the model, hence its mixed reception. There is a well-known debate in the literature between professors Schneider (Dell'Anno, Schneider 2006) and Breusch (2005) considering the substantive correctness of applying the MIMIC method in SE research.

It turns out that the best strategy is to perform numerous statistical tests[5].

5 In most cases, to assess the fit quality of the SEM, measures are used that make it possible to compare the estimated model with the saturated model (i.e. assuming that all variables are correlated with each other) and the independent model (i.e. where there is no correlation between any of the pairs of variables). The following indices are used in SEM-related literature and software: IFI (Incremental Fit Index), TLI (Tucker-Lewis Fit Index), RFI (Relative Fit Index), NFI (Normed Fit Index), CFI (Comparative Fit Index). In addition to these measures, RMSEA (Root Mean Square Error of Approximation) is also determined (Bollen 1989).

Reconstructing the theory in structural terms requires:

- an analysis of the theoretical basis of the phenomenon being studied;
- the formulation of statements concerning the set of variables;
- the a priori establishment of links between the variables, i.e. the specification of the SEM form.

In contrast to the traditional approach, the parameters are not estimated at this stage. The specification covers the construction of a system of two types of equations:

- A structural model (also called an internal model, casual model, or substantival process model) – it reflects interrelationships among constructs and tests proposed casual relationships (reflecting a verifiable theory);
- A measurement model (also called an external model) – it represents the theory that specifies how measured variables come together to represent the unobservable variables (it represents the results of confirmatory factor analysis, making it possible to calculate the loads of individual factors that shape a latent variable).

When trying to apply the SEM, it should be remembered that for a given set of observable variables, it is usually possible to determine many models that present different theoretical consequences but that have an equal fit to the empirical data.

The generally accepted way to present SEM is a path diagram, which is then transformed into a set of equations. The system of equations is solved to test the model fit and estimate the parameters. In the literature (Schneider 2005; Kline 2011; Konarski 2014; Medina and Schneider 2018), the following notation is adopted: observable exogenous (X) and endogenous variables (Y), latent exogenous (ζ) and endogenous variables (η).

It is convenient to consider the SEM (in a general case) in the form of a matrix:

$$\eta = B\eta + \Gamma\zeta + \xi \tag{1}$$

$$X = \Lambda_x\zeta + \delta \tag{2}$$

$$Y = \Lambda_y\eta + \varepsilon \tag{3}$$

where:

$\eta_{m\times 1}$ – vector of hidden endogenous variables, $\zeta_{k\times 1}$ – vector of hidden exogenous variables, $B_{m\times m}$ – matrix of regression coefficients with endogenous variables, $\Gamma_{m\times k}$ – matrix of coefficients with exogenous variables, $\xi_{m\times 1}$ – vector of random components, $Y_{p\times 1}$ – vector of observable endogenous variables, $X_{q\times 1}$ – vector of observable exogenous variables, Λ_x, Λ_y – factorial charge matrices, $\delta_{q\times 1}$, $\varepsilon_{p\times 1}$ – measurement error vectors, $E\left[\zeta\zeta^T\right] = \Phi$, $E\left[\xi\xi^T\right] = \Psi$, $E\left[\delta\delta^T\right] = \Theta_\delta$, $E\left[\varepsilon\varepsilon^T\right] = \Theta_\varepsilon$.

According to the standard approach of the SEM, the following is assumed:

$$E[\xi] = E[\delta] = E[\varepsilon] = 0,$$
$$cov[\zeta, e^T] = cov[\zeta, \delta^T] = 0,$$
$$cov[\eta, \varepsilon^T] = cov[\varepsilon_i, \varepsilon_{j \neq i}] = cov[\delta_i, \delta_{j \neq i}] = 0,$$
$$cov[\zeta_i, \zeta_{j \neq i}] = \varphi_{ji},$$
$$det(I - B) \neq 0.$$

In practice, the model proposed at the specification stage may not have been identified. The lack of traceability of the model parameters occurs when there is no unequivocal solution to the structural and measurement equations that meet the assessment criterion. The conditions for the traceability of SEMs were formulated by Bollen (1989) in the form of several rules. The most general rule is the t rule (which is a necessary but not a sufficient condition), which states that the number of unknown parameters of the t model should satisfy the inequality $t \leq \frac{(p+q)(p+q+1)}{2}$, where $p+q$ is the number of all observable variables (endogenous and exogenous).

The equation of observable variables introduced into the SEM is not always used to describe the relationships between the variables measured during the survey but to extract significant information from these values in the context of the survey and eliminate disturbances (Konarski 2014). The purpose of the model is to describe the strength and direction of individual relationships (covariance) between observable variables. In the SEM approach, it is implemented by verifying the hypothesis that the proposed model is correct if the covariance matrix Σ observed in the population is accurately reproduced (implied) by the proposed model of the theoretical process[6]:

$$\Sigma = \Sigma(\theta), \tag{4}$$

where θ is a vector of parameters of the postulated model, and $\Sigma(\theta)$ is a matrix of covariance of observable variables expressed as a function of the parameter vector θ.

Generally, the implied covariance matrix (4) is expressed in the following form:

$$\Sigma(\theta) = \begin{bmatrix} \Sigma_{yy}(\theta) & \Sigma_{yx}(\theta) \\ \Sigma_{yx}(\theta) & \Sigma_{xx}(\theta) \end{bmatrix} \tag{5}$$

6 The essence of estimating parameters depends on finding values for those parameters that result in theoretical correlations that match the possible values of empirical correlations as closely as possible.

where the reduced form of equation (1), that is $\eta = \left(I - B\right)^{-1}\left(\Gamma\zeta + \xi\right)$, is used to determine the matrix:

$$\Sigma\left(\theta\right) = \begin{bmatrix} \Lambda_y\left(I - B\right)^{-1}\left(\Gamma\Phi\Gamma^T + \Psi\right)\left(\left(I - B\right)^{-1}\right)^T\Lambda_y^T + \Theta_\varepsilon & \Lambda_y\left(I - B\right)^{-1}\Gamma\Phi\Lambda_x^T \\ \Lambda_x\Phi\Gamma^T\left(\left(I - B\right)^{-1}\right)^T\Lambda_y^T & \Lambda_x\Phi\Lambda_x^T + \Theta_\delta \end{bmatrix}. \quad (6)$$

Parameter estimation methods require the definition of an appropriate function (F) that, when minimised, determines an accurate fitting of the implied covariance matrix to the empirical data covariance matrix S, i.e, $\mathrm{F}\left(\mathrm{S},\ \Sigma\left(\hat{\theta}\right)\right)$.

Expressing the model in the implied form (4) and verifying the condition of model identification are key elements of its specification. In practice, estimation is conducted by solving a system of equations using one of the iterative methods:

- the maximum likelihood method (assuming that the distribution is a multidimensional normal distribution);
- the generalised least squares method (which requires a large sample, i.e., more than 2500 observations);
- ADF (an augmented Dickey–Fuller test) methods (insensitive to distribution, cf. Konarski 2014).

At the end of the twentieth century, Jöreskog (1973) and Jöreskog and Sörbom (1993) developed an original program to estimate and verify the linear form of the SEMLIS-REL model (LInear Structural RELations). Since then, new opportunities brought about by the development of the computer market and the software industry have increased the number of programmes, making way for a variety of SEM applications. The most frequently used software include the following: Mplus, SPSS (Amos), STATISTICA (SE-PATH), R (SEM, Lavaan), SAS/STAT (CALIS), and Stata.

If the estimated theoretical model is correctly verified[7], then the identified and estimated relationships and the strength of their influence will provide accurate information about the causal process underlying these variables (i.e. the substantial process). SEM calculations are not difficult to perform thanks to the specialised software mentioned above. The problem is using it accurately and to correctly interpret the results.

7 It will be confirmed in the analysed set of observations.

Proposal for an SEM to measure the shadow economy

The idea behind the proposed approach depends on three facts being considered: 1) The estimated size of the SE, as it is not directly observed, is represented by a rich set of observable variables ($X_1, \ldots X_9$) and (Y_1, Y_2, Y_3). 2) Its existence determines the functioning of various economic spheres (processes) (measurable employing specific macroeconomic indicators). 3) The complexity of the economy – a strong interdependence and the interrelationship of various economic spheres.

A list of variables has been proposed and their interdependencies determined in light of the above (Figure 1). This was done bearing in mind the unique characteristics of Poland, based on both theoretical considerations and empirical research carried out by other researchers in Poland and other countries (in particular: Mróz 2002; Schneider 2005; Cichocki 2006; Grzegorzewska-Mischka and Wyrzykowski 2015; Buehn and Schneider 2016; Dymarski 2016; Dybka et al. 2017; Błasiak 2018; Medina and Schneider 2018; Misztal 2018; Fundowicz et al. 2019; Malczewska 2019) and the experience of the authors derived from estimating the SE in Statistics Poland.

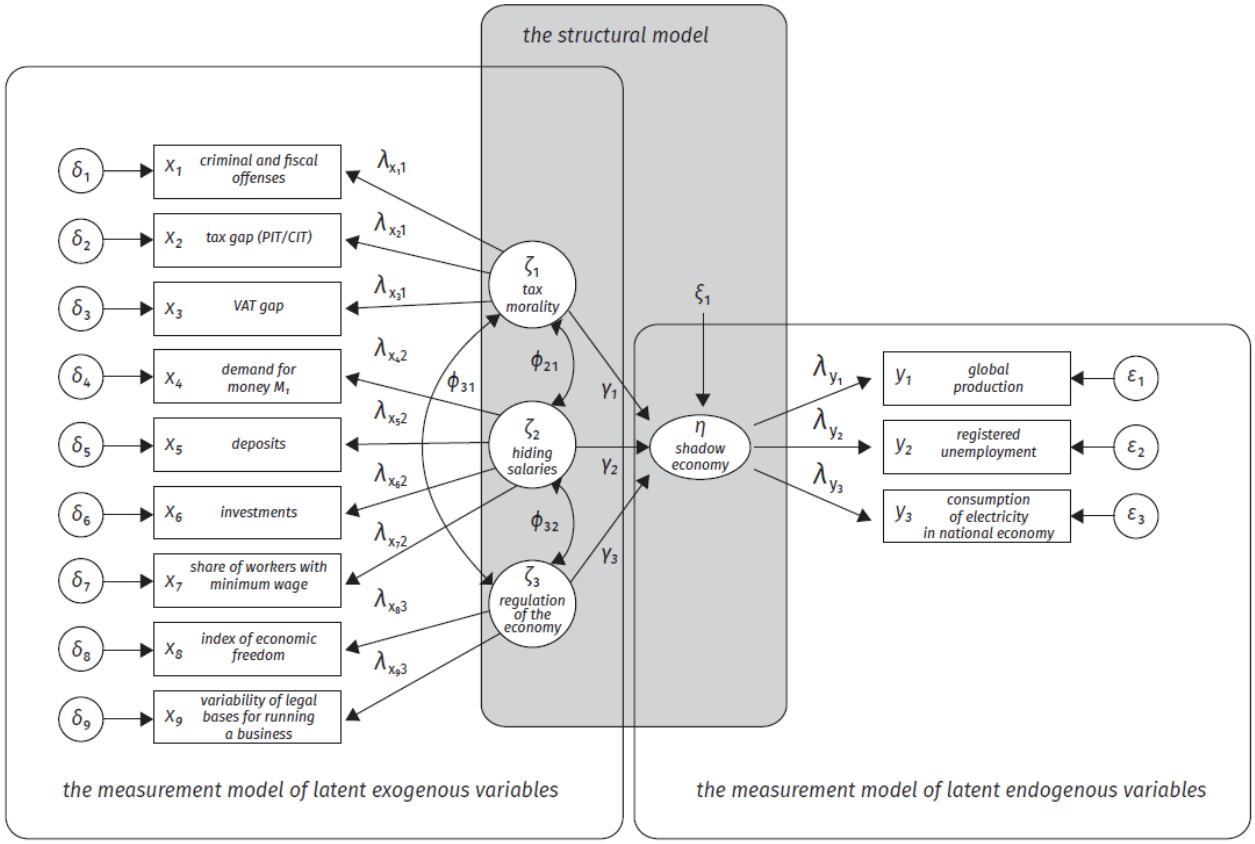

Figure 1. Original SEM describing the internal and external model of the model hypothesis concerning the determinants of the level of the SE in Poland

Source: own elaboration.

In order to overcome the limitations of fragmentation caused by the one-dimensionality of the model (i.e. estimating the SE by e.g. measuring the consumption of electricity (Lackó 2000) or by a monetary approach based on the analysis of the amount of money in circulation[8]), three dimensions have been taken into account in the above model (Y_1, Y_2, Y_3), which reflect the size of the SE.

The innovation of the proposed approach (Figure 1) involves replacing the previously considered MIMIC type models (which contain only endogenous latent[9] variables) with the SEM type. The SEM type combines the structural model with the model (the submodel) that measures exogenous latent variables (i.e. the factor analysis model) (see Figure 2).

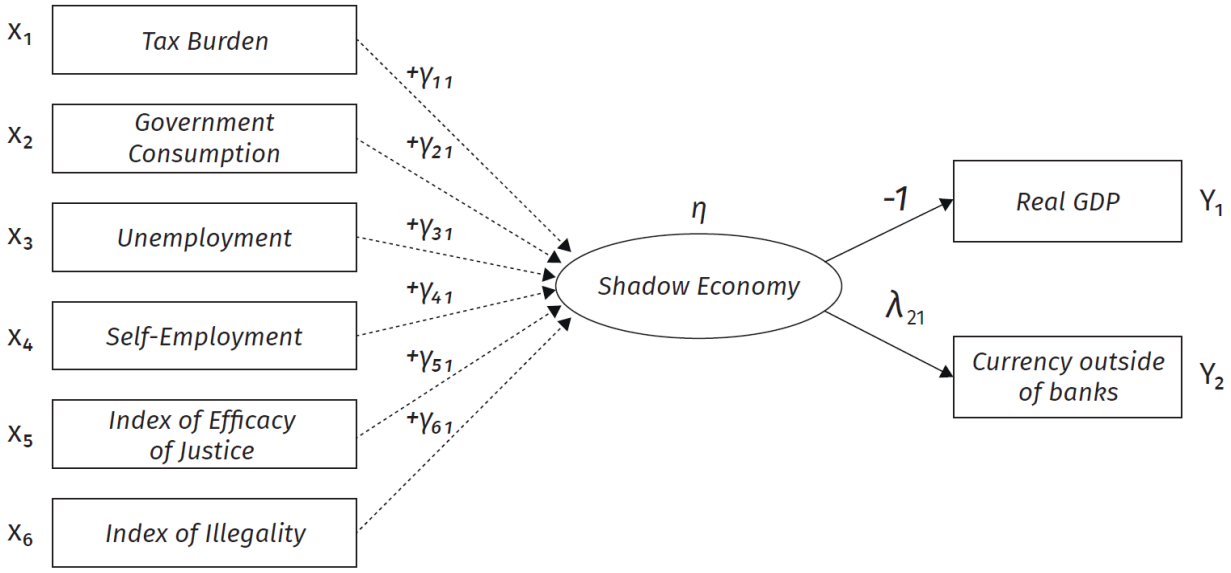

Figure 2. Schneider's MIMIC model of the shadow economy – an international perspective

Source: Dell'Anno and Schneider (2003).

The proposed concept of modelling SE considers that there are unobserved exogenous variables (ζ_1, ζ_2, ζ_3) (theoretical constructs, latent factors) which reflect the causes of the SE. In the proposed model (Figure 1), the reflective approach of defining a hidden variable has been used[10]. Each of the ζ_i constructs has its empirical argumentation in measurable indicators (for ζ_1 they are observational indicators X_1, X_2, X_3, for ζ_2 – observational indicators X_4, X_5, X_6, X_7 and for ζ_3 – indicators X_8, X_9). Furthermore, the model assumes

8 Dymarski (2016) reviewed such models in his doctoral dissertation.

9 Frey and Weck-Hanneman (1984), Dell'Anno and Schneider (2006) and Medina and Schneider (2018) estimated the SE using the MIMIC methodology.

10 The use of a reflective approach implies the assumption that a hidden variable exists and is strongly correlated with observable variables that are the result of the interaction of the hidden variable(s) (Gatnar 2003). The assumed direction of causal flow results from the fact that, e.g., an increase in tax morality means a simultaneous change in the adopted indicators, and it is not expected that direct manipulation of a specific indicator will have a causal impact on a hidden variable.

the existence of a correlation between constructs ζ_1, ζ_2 and ζ_3, which in practice means assuming that the sources of covariance $\phi_{21}, \phi_{31}, \phi_{32}$ are outside the scope of the model.

Such a solution is a chance to eliminate one of the basic objections concerning the assumption made in the MIMIC method, i.e., that variables that act as indicators (and/or determinants) in the model interact only through the endogenous latent variable, i.e., the SE (Dymarski 2016).

In the approach proposed by Schneider (2005) (Figure 2), the causality direction leads from the exogenous observable variables to a hidden variable. This is the formative way of determining a hidden variable (the formative indicators model), the essence of which is the assumption that observable variables (indicators) are hypothetical reasons for the existence of a hidden variable (Bollen 1989). In this approach, the hidden variable does not have to actually exist (Kaplan 2000; Gatnar 2003). Of course, considering more observable variables minimises estimation errors, allowing us to obtain a more reliable and complete picture of the analysed unobservable variable.

The model assumes that the path to shaping the size of the SE is reflected by changes in the level of global production, the rate of registered unemployment, and the size of electricity consumption in the national economy. The size of production depends on the situation in the labour market, and changes in energy consumption are strongly correlated with changes in the size of production (this interdependence results from, among other things, the indirect relationship between the variables, precisely since the SE exists).

Three factors that are not directly observable are proposed as determinants of activity being undertaken in the shadow sphere, i.e., tax morality, concealing salaries, and regulation of the economy. Their task is to reflect information about various (multifaceted) reasons that play an important role in making decisions on how business owners function in the shadow economy.

Finally, the process of data collection, which will provide the theoretical model with the proposed variables is tedious and time-consuming. It requires a broad exploration of both statistical and non-statistical information resources (e.g. administrative data sources, the results of the work of research centres) while maintaining methodological reliability in terms of their comparability in longer time series.

Conclusions

The issues discussed in the article have been discussed for many years. The SE (its causes, consequences, measurement, and evaluation) is still of interest to experts in many fields of academia: sociology, psychology, banking, finance, economics, and statistics.

Despite the passage of time, it still causes difficulties not only in terms of reliable measurement but also in terms of interpreting results. The complexity of the SE means that it is still a problem to find a reliable way to measure and analyse it.

The review of national practices in selected EU countries showed different approaches to estimating the SE and publishing results. This article presents the idea of a developed methodology based on the SEM technique with latent variables. SEM is a combination of techniques that allow multivariate data analysis enriched by the aspect of causality. This makes it possible to capture and explain empirical phenomena more precisely and effectively than with classical methods of statistics and econometrics.

In the literature on the subject, there are studies being conducted based on a special case of the SEM, i.e. the MIMIC rule. The originality of our approach proposed is based on the introduction of exogenous latent variables, which give a better chance to accurately estimate the SE. As a result, the research approach presented in the article will provide a new, objective quality in estimating the size of the SE, and it will deepen our knowledge about its complex structure. The identification of important reasons that determine the existence of the SE will make it possible to better estimate indicators provided by public statistics while indicating the potential directions for limiting its functioning and development.

The presented model is a starting point for further research. There is a high probability that many SEMs will need to be tested and modified to achieve the final result.

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Koncepcja modeli równań strukturalnych w pomiarze szarej strefy – perspektywa międzynarodowa i polska

W artykule podjęto próbę zaprezentowania niewykorzystanego potencjału eksplikacyjnego modelu równań strukturalnych oraz jego specyfikacji w kontekście pomiaru szarej strefy. Szara strefa jako zjawisko interdyscyplinarne budzi wiele pytań i kontrowersji wśród badaczy oraz urzędów statystycznych w wielu krajach. W artykule zaprezentowano różne podejścia krajów w tym zakresie, ze szczególnym uwzględnieniem Włoch i Polski. Jedną z najważniejszych trudności stanowi brak możliwości przeprowadzania bezpośredniego pomiaru wielkości tego zjawiska. Rozwiązaniem tego problemu w opinii autorów jest zastosowanie modeli ze zmiennymi nieobserwowalnymi. Złożoność szarej strefy wymaga uwzględnienia nie tylko prostych relacji między zmiennymi zależnymi i niezależnymi (a właściwie endogenicznymi i egzogenicznymi), równie istotne dla poprawności analizy jest zbadanie związków między samymi zmiennymi o charakterze zależnym lub niezależnym. Powyższe fakty skłaniają do zastosowania niestandardowych technik umożliwiających modelowanie złożonych relacji między zmiennymi oraz uwzględnienie, a następnie szacowanie zmiennych nieobserwowalnych. Artykuł ma charakter przeglądowo-konceptualny i jest przyczynkiem w międzynarodowej dyskusji dotyczącej doskonalenia technik szacowania szarej strefy.

Słowa kluczowe: szara strefa, krajowe urzędy statystyczne, modele równań strukturalnych, zmienne nieobserwowane, gospodarka międzynarodowa

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.15

The Efficiency of Labor Market Policies in EU Countries

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Abstract

The objective of this paper is to examine the efficiency of the public sector when it comes to labor market policy (LMP) in European Union (EU) countries. The primary aim is to provide a comprehensive evaluation of public services connected with the LMP from the viewpoint of the efficiency of public expenditure allocated for that purpose. The turning point for the European labor market was marked by the introduction of lockdown in 2020 due to the COVID–19 pandemic. The article's overall aim is to evaluate the efficiency of EU labor markets before and during the pandemic and to ascertain the extent to which the volume of public services (their financial allocations) affects selected labor market indicators.

The efficiency of EU countries in 2019 and 2020 was evaluated by applying the Data Envelopment Analysis (DEA) method. The BCC (Banker, Charnes, Cooper) model was used in this study. The output-oriented BCC model was selected as it seems adaptable to the specifics of the LMP. Microsoft Excel Solver was used for solving the DEA model, which is applied to working out linear optimization models. The efficiency of public expenditure was evaluated using data from Eurostat. A total of seven variables were used for the analysis; they comprised five variables as inputs (government expenditure on services by selected function and two uncontrolled inputs represented by job vacancy rate and GDP per capita) and two variables as outputs of selected labor market indicators (employment rate and unemployment rate <inverted indicator>). The cross-country comparison was conducted in two dimensions – among individual EU countries and among a group of countries that represent different public administration traditions (i.e., Anglo-Saxon, Continental European, South European, Scandinavian, Eastern European, and South-Eastern European).

Received: 1.08.2023. Verified: 18.10.2023. Accepted: 28.03.2024

The study demonstrates that even though the Southern countries achieved the worst results in terms of labor market indicators, it is in contrast to the efficiency approach using DEA, where countries such as Portugal and Greece achieved full efficiency for both 2019 and 2020. The efficiency approach of the LMP for 2019 and 2020 indicates that there is a very good situation in Central and Eastern European countries. Full efficiency is also achieved by Cyprus, Malta, Sweden and Germany. The least efficient LMP is found in Belgium.
During the pandemic, most of the analyzed groups of countries improved their efficiency scores of public expenditure on LMP. The exceptions were groups of countries with the South European tradition and the Scandinavian tradition, where the measure of efficiency decreased slightly. This may demonstrate the effectiveness of the implemented public policy to counteract the negative effects of COVID–19 on the labor market.
The value added of this paper comes from the demonstration that the proposed methodology, using the DEA method, can be used to measure the efficiency of LMP at micro- and mezzo-levels and to make cross-country comparisons.

Keywords: efficiency, public services, labor market policy, DEA method, EU countries, public administration tradition

JEL: E02, E24, J01, J08

Introduction

Public services, provided under the labor market policy (LMP), support economic growth by emphasizing the quality, development, and cultivation of human potential (Halaskova, Halaskova, and Prokop 2018). From the viewpoint of theoretical approaches, the theory of state and public financing raises the question of the state's provision of public services (including labor market services). Adam Smith (1976) emphasized the significance of ensuring services for the public benefit that the market is uninterested in due to their unprofitability. Stejskal and Hajek (2015) noted that in relation to the provision of public services, the efficiency of taxation and public expenditure is becoming a matter of interest. Studies have also investigated the connection between measuring performance and public service efficiency (Greiling 2006). However, the efficiency of public services is very often treated as something more than a technical relationship between resources and output. It extends allocative efficiency, which is defined as the optimal combination of inputs so that the output is provided at a minimal cost (Baudnenko, Fritsch, and Stephan 2008). This broad perspective is due to the fact that public services have multiple goals. It is much easier to set objectives for public services in terms of meeting those goals than it is to evaluate the efficiency of resource utilization in achieving those objectives. That is why the effectiveness approach is more popular when evaluating the performance of public services. The same is true for public services provided within the LMP (Rollnik-Sadowska 2019).

The evaluation of the EU labor markets is mainly based on the effectiveness approach, as demonstrated by meeting certain labor market indicators over time. An illustrative

example is the Europe 2020 strategy, which set a target to achieve an employment rate of 75% for the working population by 2020.

The article's overall aim is to evaluate the efficiency of EU labor markets, particularly in relation to the LMP, both before and during the COVID–19 pandemic. We aim to achieve this by conducting a comprehensive assessment of public sector services, focusing on the efficiency of allocated public resources. We also aim to find the extent to which the volume of public services (its financial allocations) affects selected labor market indicators. A turning point for the European labor market was the introduction of the lockdown in 2020 due to the pandemic. To avoid a massive increase in unemployment and to protect jobs, EU countries introduced Job Retention Schemes (JRSs) or expanded existing ones, using, in part, EU funds that were mobilized through the temporary Support to Mitigate Unemployment Risks in Emergency (SURE) instrument (Ando et al. 2022).

To meet the target, the study provides empirical support for the following research questions:

RQ1: How did EU countries vary in terms of LMP efficiency before and during the pandemic?

RQ2: Do EU countries with the same tradition of public administration have a similar rate of efficiency of public expenditure on the LMP?

The cross-country comparison was conducted in two dimensions – among individual EU countries and among a group of countries that represent different public administration traditions (Anglo-Saxon, Continental European, South European, Scandinavian, Eastern European, and South-Eastern).

The rest of the paper is structured as follows. The next section covers the theoretical background to understand how efficiency is evaluated in the public sector in terms of theory and practice in the EU. Section 3 details the research methodology and characteristics of the dataset. Section 4 presents the research results. Finally, in the Discussion and Conclusion sections, the results are compared with other studies and conclusions are drawn.

Theoretical background

Public services have often been analyzed from the viewpoint of practical questions in relation to their provision and funding. Ensuring public services has a wider significance, which includes guaranteeing, organizing, regulating, and partially controlling and financing public services (Halaskova, Halaskova, and Prokop 2018). Public services financing has been analyzed by many scholars in the framework of public

finance theory, even though there is no single source or tool for the provision of financing public services (Cullis and Jones 2009).

Public expenditure plays a significant role in financing public services, serving as a prerequisite for access to these services as well as their development. Numerous papers have analyzed public expenditure, its changes and its increased efficiency. For instance, Szarowska (2014) examined long-term and short-term relationships between government expenditure and GDP in the EU15. Meanwhile, Agénor and Neanidis (2011) evaluated the relationship between public expenditure and economic growth. Many authors (e.g., Afonso, Schuknecht, and Tanzi 2005; Schaltegger and Torgler 2006; Curristine, Lonti, and Joumard 2007; Mericková and Stejskal 2014) have pointed to increased efficiency of public expenditure in relation to financing public goods and services. They looked for ways to provide public resources more efficiently and accordingly proposed measures for improvement.

Two concepts are inherent in the discourse on public expenditure: efficiency and effectiveness. Public administration efficiency is a wider concept than a technical relationship between resources and output or allocative efficiency, which is defined as the optimal combination of inputs so that the output is provided at a minimal cost (Baudnenko, Fritsch, and Stephan 2008). It has another dimension, which incorporates outputs in relation to values and accountability as an inherent quality of democratic governance (Manzoor 2014). Rutgers and van der Meer (2010) claim that two different meanings of efficiency in public administration can be used: a technical term, which concerns the link between resources and results, and a more substantive meaning, which concerns professional actions and organization, and ensuring compliance with the execution of legal rules and regulations. Rutgers and van der Meer also claim that there might even be a conflict between the measure of efficiency and the other values, and/or it may be impossible to establish priority among the multiple goals. Meanwhile, effectiveness is the degree to which goals have been achieved (Rollnik-Sadowska 2019).

The evaluation of public sector and public service efficiency has also been elaborated on at the macroeconomic level. This approach is based on the definition of the link between public sector performance and efficiency. Afonso, Schuknecht, and Tanzi (2005), for instance, assumed that public sector performance is dependent upon improved values of selected socioeconomic indicators. Other authors have analyzed the efficiency of public expenditure in areas of public services in relation to macroeconomic indicators. Tkacheva, Afanasjeva, and Goncharenko (2017), for instance, examined public expenditure on social support, education, and health care. They showed that once social costs begin to outpace the GDP growth rate, there is a decrease in economic development rates.

Mericková et al. (2017) evaluated the correlation between the volume and structure of public expenditure and socioeconomic development as represented by the Human Development Index. They indicated that the total amount of public expenditure does not

have a significant impact on socioeconomic development; however, public expenditure in "productive" sectors of public services (especially education, health, and social services) has the potential to positively impact socioeconomic development. Mandl, Adriaan, and Ilzkovitz (2008) showed that the efficiency of public services in general, and public expenditure on education and R&D in particular, varies significantly between countries. They also illustrated the difficulties of measuring efficiency and effectiveness. Rollnik-Sadowska and Dąbrowska (2018) studied expenditures on labor-market-policy public and demonstrated that EU countries are diversified in those terms.

Selecting a method for measuring the efficiency of public services is challenging. The literature distinguishes three approaches: the indicator approach, and parametric and non-parametric methods (Rollnik-Sadowska 2019). The indicator approach considers one perspective of obtaining certain outputs; hence, it does not represent the efficiency attitude but the effectiveness approach. The parametric methods require that a production function be established. However, the multidimensional outcomes of public services make it difficult to observe all possible combinations of input and output data and to specify the mathematical form of the production function. However, in non-parametric methods, there is no such requirement. The non-parametric approach is more flexible, as it is used in models whose structure is not established a priori but adapted to the data (Rutkowska 2013). In the non-parametric approach, the linear programming procedure is used, and the influence of a random factor on the efficiency of the objects and potential measurement errors are not considered. It is important to select statistically reliable variables and construct a model that considers both the inputs and outputs of certain public services provided by the decision-making units. In addition, it is possible to consider environmental variables that determine the activity of given decision-making units (Curristine, Lonti, and Joumard 2007).

A popular non-parametric method used to evaluate the efficiency of public services is data envelopment analysis (DEA). DEA is a linear programming approach used as a model–specialized tool to assess the efficiency, performance, and productivity of comparable production units (homogeneous decision-making units – DMUs) based on the size of inputs and outputs. It is based on technical efficiency, defined as the ability to optimize the use of resources by maximizing the outputs achieved at a given level of inputs (outputs-oriented efficiency) or minimizing expenditures with a certain amount of outputs (input-oriented efficiency) (Rollnik-Sadowska 2019). The DEA method has been used in various applications to assess the environmental performance of units of different scales, i.e., regions, countries, provinces, sectors, and firms (Chodakowska and Nazarko 2017). For example, Dutu and Sicari (2016) used DEA to assess the efficiency of welfare spending using a sample of OECD countries around the year 2012, focusing on health care, secondary education, and general public services. Cichowicz et al. (2021) implemented a two-stage DEA to measure the efficiency of public employment services in a Polish

voivodship. The DEA method has also been used on a macro level for country evaluations, allowing for a cross-national comparison (Zaim and Taskin 2000; Färe, Grosskopf, and Hernandez-Sancho 2004; Zhou, Poh, and Ang 2007; Lozano and Gutiérrez 2008; Zhou, Ang, and Wang 2012; Li and Wang 2014 or Chodakowska and Nazarko 2017).

Research methodology

We evaluated the efficiency of EU countries in 2019 and 2020 by applying the DEA method. A DMU (in this case, an EU country) is efficient when it lies on the border of its productivity capabilities (efficiency frontier), which means that the country makes effective use of its inputs, transforming them into required outputs (Halaskova, Halaskova, and Prokop 2018). The model can be built on the assumption of constant returns to scale, when one unit of input generates one unit of output (CCR model proposed by Charnes, Cooper and Rhodes). It is appropriate when all DMUs operate on an optimal scale (Huguenin 2012). The rather unrealistic condition is solved by introducing variable returns to scale (VRS) that consider all types of returns, i.e., increasing, constant, or decreasing, and assuming that DMUs do not operate on an optimal scale (BCC model proposed by Banker, Charnes, and Cooper) (Halaskova, Halaskova, and Prokop 2018). The BCC model (1) was therefore used in this study.

Moreover, the output-oriented model was selected as it is adaptable to the unique conditions of the LMP. The weighted sums of outputs are maximized, holding inputs constant. In the input-oriented model, the weighted sums of inputs are minimized, holding outputs constant (Huguenin 2012). In contrast to the input-oriented DEA models, the output-oriented models try to increase outputs proportionally while keeping the existing inputs unchanged (Toloo, Keshavarz, and Hatami-Marbini 2021).

For the modeling, we considered a set of n DMUs j ($j = 1, \ldots, n$), each consuming m expenditures (inputs) x_{ij} ($x1_j, \ldots, x_{mj}$) to produce s results (outputs) y_{rj} ($y_{1j}, \ldots, y_{sj}$). The output-oriented DEA-BCC model can be defined as:

$$\max\left(\sum_{r=1}^{s} u_r y_{r0} + v_0\right) \tag{1}$$

subject to

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + v_0 \leq 0,\ j = 1,\ldots,n$$

$$v_i \geq 0, i = 1,\ldots,m$$

$$u_r \geq 0, r = 1,\ldots,s$$

v_0 free

In the model, *xij* represents the amount of input *i* of the DMU *j*; *yrj* represents the amount of output *r* of DMU *j*; xi_0 represents the amount of input *i* of the DMU; yr_0 represents the amount of output *r* of the DMU; *vi* represents the weight of input *i* for the DMU; *ur* represents the weight of output *r* for the DMU; v_0 represents the scale factor; *s* represents the number of outputs analyzed; *m* represents the number of inputs analyzed; and *n* represents the number of DMUs analyzed (in this case, EU countries).

Microsoft Excel Solver was used to solve the DEA model (Proudlove 2000; Wang 2017), which was applied to solve the linear optimization models. The Excel DEA model was formulated as a spreadsheet model and needs to be solved by running Excel Solver for each DMU (Jablonsky 2008; Zhu 2014).

In this study, the efficiency of public expenditure was evaluated using data from Eurostat. A total of seven variables were used for analysis. It comprised five variables as inputs (government expenditure on services by selected function and two uncontrolled inputs represented by job vacancy rate and GDP per capita) and two variables as outputs of the selected labor market indicators.

The following indicators were included as the input data:

I1: Expenditure on labor market services as a percentage of GDP;

I2: Expenditure on total LMP measures (categories 2–7) as a percentage of GDP;

I3: Expenditure on total LMP supports (categories 8–9) as a percentage of GDP;

UI1: Job vacancy rate;

UI2: GDP per capita in purchasing power standard (PPS).

Two variables were involved in the model as outputs:

O1: Employment rate;

O2: Unemployment rate (inverted indicator).

The set of data above is essential to assess the effectiveness and efficiency of the LMP. The expenditure on the LMP is often selected for effectiveness and efficiency analysis

at mezzo- and macro-levels (Baker et al. 2005; Rollnik-Sadowska, Dąbrowska 2018). Meanwhile, the employment rate and the unemployment rate are the most popular measures to evaluate LMP outputs on a macro-scale (Escudero 2018; Dmytrów and Bieszk-Stolorz 2021; Hohlova and Rivza 2022). Two variables were selected as uncontrolled inputs: job vacancy rate and GDP per capita in PPS. They are strongly rooted in economic theory in terms of their direct influence on unemployment and indirect influence on employment. The link between the job vacancy rate and the unemployment rate, known as the Beveridge curve, is widely described in the literature (e.g., Saglam and Gunalp 2012; Christl 2020). Meanwhile, Okun's law presents the relationship between unemployment and GDP. It suggests that there is a negative relationship between movements of the unemployment rate and real GDP (Okun 1962; Pizzo 2020; Rollnik-Sadowska and Jarocka 2021).

The data analysis was conducted for two years – 2019 and 2020 – to identify the influence of the COVID–19 pandemic on the labor market efficiency of EU countries. We selected 2019 for the analysis as it represents a before-pandemic year; 2020 was selected as it was the beginning of the COVID–19 pandemic in the EU, and this was the last year when all data for the analyzed variables were available.

Research results

By using the effectiveness approach, the EU labor market situation can be analyzed from the perspective of labor market indicators, with the most common being the employment rate and the unemployment rate. Regarding the employment rate and meeting the target of the Europe 2020 strategy, the Netherlands and Sweden had the highest indicators (over 80%) both in 2019 and 2020, undoubtedly influenced by widespread labor market flexibility in those countries (see Figure 1). Denmark, Lithuania, Latvia and Finland also met the target employment rate in both years. Meanwhile, in 2019, before they implemented restrictions connected with the COVID–19 lockdowns, Germany, Czechia and Estonia achieved very high employment rate levels (over 80%). In 2019, Austria, Slovenia and Portugal achieved an employment rate of 75%. In 2020, most EU countries observed a drop in the employment rate (the most severe was in Romania, by 5.7 p.p.). However, in Slovakia, the Netherlands, Malta, Croatia, and Hungary, slight growths were noted in 2020 compared to 2019. The lowest level for both years was registered in Greece and Italy.

The lowest unemployment rates in 2019 and 2020 were registered in Czechia, Poland, Germany, and the Netherlands (see Figure 2). The Czech model of economic development is strongly based on cooperation with Germany (Krpec and Hodulák 2018) and is supported by the fact that Czechia is outside the eurozone. Poland, as the biggest CEE economy, has been a great beneficiary of EU funds and has seen significant economic

growth. It saw the greatest drops in the unemployment rate after joining the EU compared to other CEE members of the EU (Rollnik-Sadowska and Jarocka, 2021). Germany manifests a strong corporate model economy with a significant labor demand and an effective educational system that prevents structural unemployment (Schels and Wöhrer 2022). While the Netherlands, as mentioned above, has a flexible and inclusive labormarket (Yu 2023), it was Greece and Spain that were the leaders regarding the unemployment rate level.

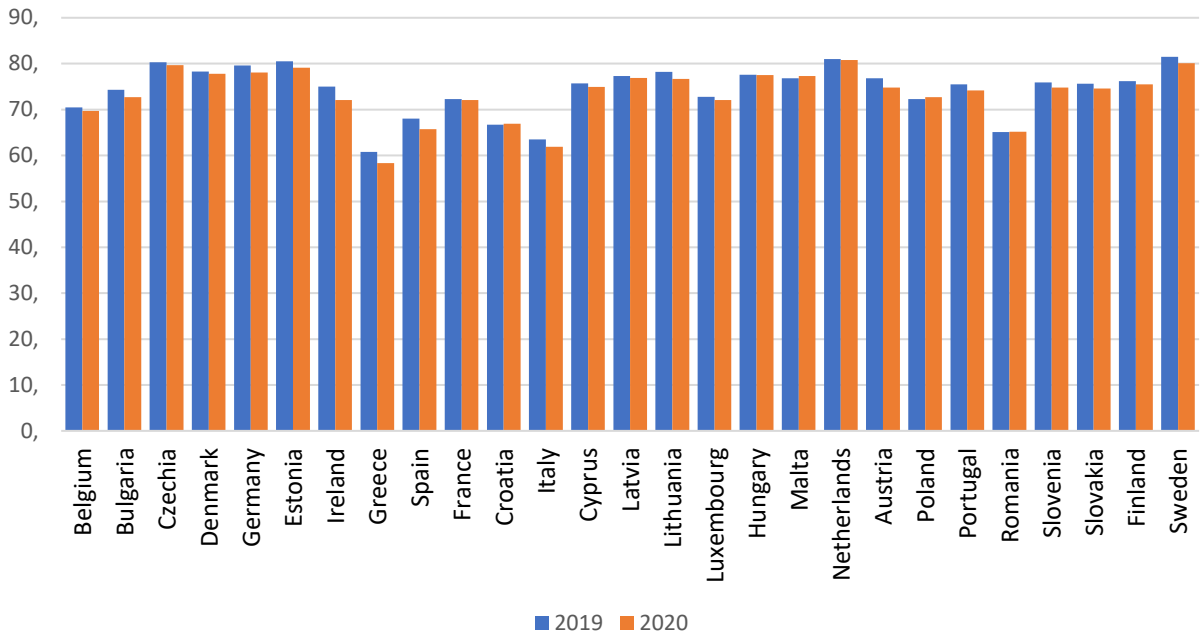

Figure 1. Employment rate in EU countries, 2019 and 2020 (%)

Source: Eurostat (2024a).

In 2020, most EU countries saw an increase in the unemployment indicator as a result of the lockdown measures, with many workers who lost their jobs unable to seek work owing to mobility restrictions. However, although the indicator grew, it was not significant, and some countries (Italy, France, Poland) recorded a drop in the unemployment rate. Job retention schemes averted potential redundancies and replaced them with temporary layoffs and reductions in working hours. Moreover, the workers who lost their jobs and were unable to seek work owing to mobility restrictions were not considered unemployed under the conventional measure of unemployment (Gómez and Montero 2020).

The above-mentioned results of the analysis of the labor market represent the effectiveness approach as it relates to the achieved outputs on the labor market (in terms of employment and the unemployed). The efficiency approach requires a simultaneous consideration of both inputs and outputs. The implementation of the primary research objective, which examined the efficiency of the public sector regarding

the LMP in individual EU countries, was ensured by the use of the DEA method. Five variables were included in the basic model, and additionally, for comparison, two environmental variables were considered (see Figure 3).

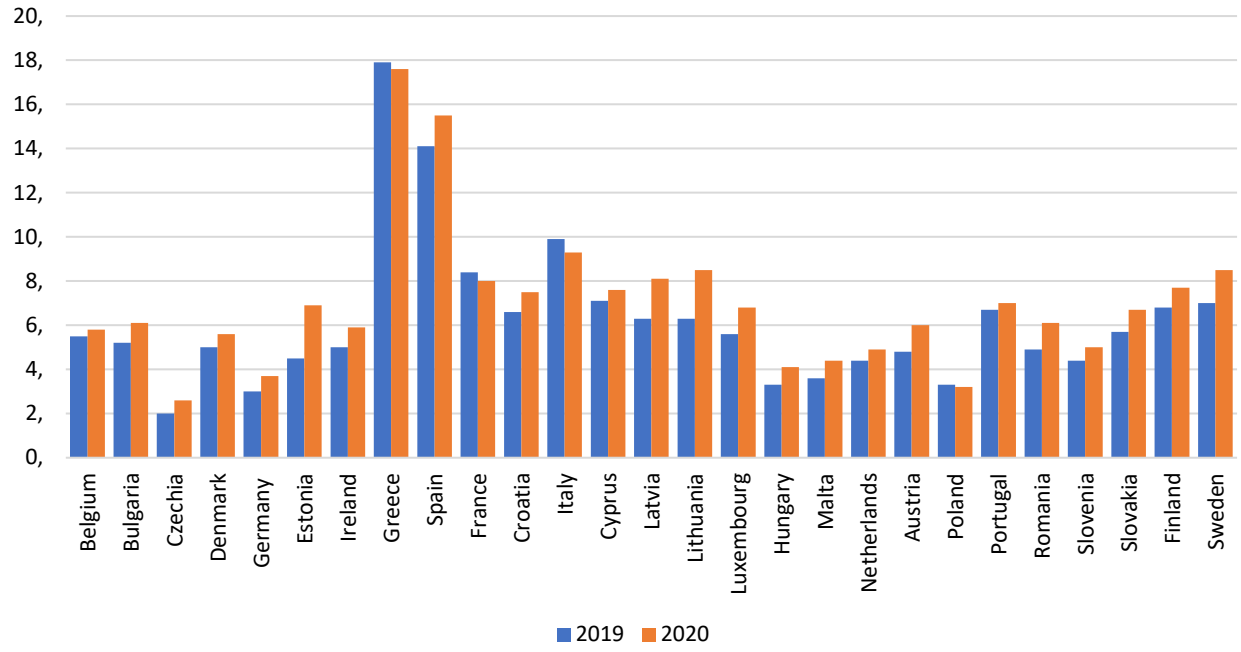

Figure 2. Unemployment rate in EU countries, 2019 and 2020 (%)

Source: Eurostat (2024b).

As mentioned above, to evaluate the LMP in the EU, the study incorporated the BCC output-oriented model. The model provides information on how much, on average, the outputs could be increased in order for a given country to become efficient with the same amount of inputs.

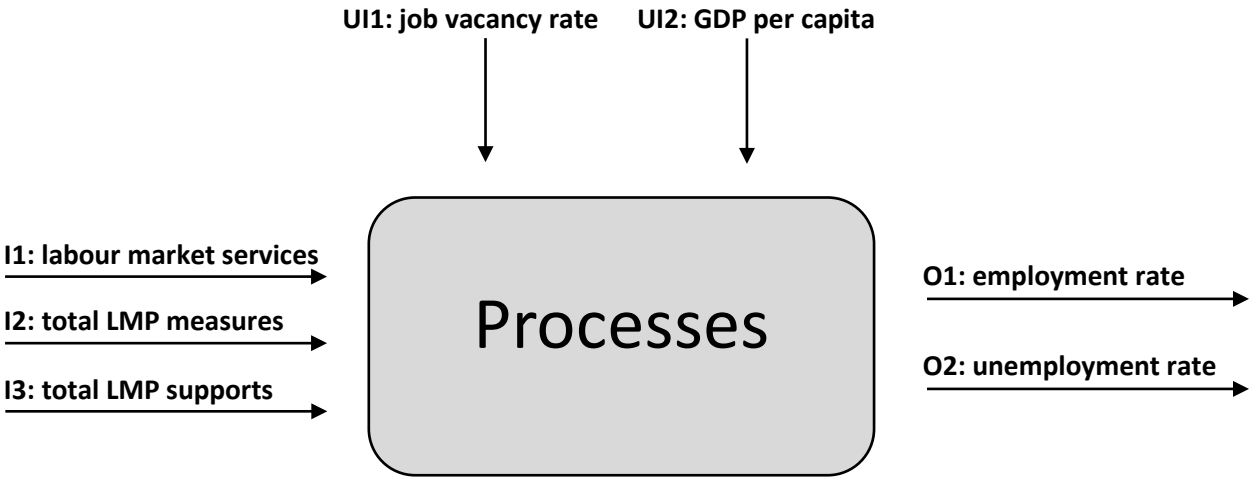

Figure 3. Model of the technical efficiency of EU labor market policies

Source: own study based on Rollnik-Sadowska (2019).

The calculations of technical efficiency were made for two years, 2019 and 2020. They consider four models due to the adopted environmental variables (U1 or U2). The first model only includes the job vacancy rate (U1), the second considers GDP per capita (U2), the third covers the option with both environmental variables, while the fourth does not include any of the uncontrolled variables.

The results of the output-oriented VRS model are shown in Table 1. Efficient countries reached an efficiency rate of 1. Countries that did not reach 1 were not considered efficient (a rate lower than 1 means the country is less efficient).

Table 1. Technical efficiency of EU labor markets in 2019 and 2020

Country	2019 with U1	2019 with U2	2019 with U1 & U2	2019 without U1 or U2	2020 with U1	2020 with U2	2020 with U1 & U2	2020 without U1 or U2
Czechia	1	1	1	1	1	1	1	1
Greece	1	1	1	1	1	1	1	1
Cyprus	1	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1	1
Romania	1	1	1	1	1	1	1	1
Sweden	1	1	1	1	1	1	1	1
Bulgaria	1	1	1	1	1	1	1	0.994528
Lithuania	1	1	1	1	1	0.812358	1	0.708772
Germany	1	1	1	1	1	0.668522	1	0.581308
Portugal	1	1	1	0.873078	1	0.787200	1	0.347752
Estonia	1	1	1	0.777778	1	1	1	0.651016
Poland	1	0.969299	1	0.577339	1	1	1	1
Spain	1	0.582418	1	0.139831	0.899371	0.601648	0.899371	0.138969
Latvia	0.991160	1	1	0.991160	1	1	1	1
Ireland	0.973937	0.89238	0.973937	0.89238	1	1	1	1
Hungary	0.92813	0.959738	0.972314	0.871363	1	1	1	1
Netherlands	0.879429	0.691039	0.879429	0.629630	1	1	1	1
Slovakia	0.860717	0.832985	0.860717	0.625055	1	0.950813	1	0.884802
Slovenia	0.845113	0.806322	0.882861	0.744459	1	0.849097	1	0.695964
Italy	0.776471	0.776471	0.776471	0.776471	0.717895	0.700477	0.724544	0.623051
Denmark	0.748209	0.566786	0.748209	0.216216	0.724992	0.586630	0.724992	0.259205
Croatia	0.656085	0.910959	0.910959	0.319209	0.640717	0.943091	0.998406	0.315653

Country	2019 with U1	2019 with U2	2019 with U1 & U2	2019 without U1 or U2	2020 with U1	2020 with U2	2020 with U1 & U2	2020 without U1 or U2
France	0.637 199	0.5	0.637 199	0.086 569	0.578 506	0.593 939	0.670 089	0.135 233
Finland	0.550 487	0.614 234	0.634 570	0.365 959	0.654 485	0.584 098	0.654 495	0.318 892
Luxem-bourg	0.548 018	0.300 428	0.548 018	0.300 428	0.61 434	0.38 196	0.614 348	0.381 965
Austria	0.423 427	0.508 514	0.508 514	0.263 672	0.473 592	0.525 014	0.565 517	0.208 090
Belgium	0.261 593	0.449 153	0.449 153	0.057 642	0.314 812	0.539 195	0.556 366	0.126 190

Source: own study using Microsoft Excel Solver.

In 2019, the fully efficient countries in terms of transforming LMP expenditures into a high employment rate and a low unemployment rate, including both environmental variables, were Czechia, Greece, Cyprus, Malta, Romania, Sweden, Bulgaria, Lithuania, Germany, Portugal, Estonia, Spain and Latvia.

In 2020, Spain left the group of fully efficient EU countries, along with Ireland, the Netherlands, Hungary, Slovakia and Slovenia.

The lowest efficiency for both analyzed years was observed in Belgium, Austria, Luxembourg, Finland and France.

It is noticeable that the inclusion of uncontrolled variables in the model improved the efficiency of labor market expenditures for all EU countries, both in 2019 and 2020. With the exception of Spain, Italy, and Denmark, the efficiency of the EU labor markets increased in 2020 compared to 2019.

The EU countries can also be compared in terms of the efficiency of public expenditure on LMP, including their public administration tradition. This part of the analysis was connected with research question RQ2: Do EU countries with the same tradition of public administration have a similar rate of efficiency of public expenditure on the LMP? According to Demmke (2008), EU countries can be assigned to six different models of public administration and human resource management traditions. Table 2 compares the EU states by the efficiency of public expenditures on LMP in 2019 and 2020.

Based on the data in Table 2, countries with the Eastern European tradition (Czechia, Hungary, Slovakia, Poland, Lithuania, Latvia) and South-Eastern tradition (Bulgaria, Romania, Croatia) are the most homogeneity in terms of efficiency, both in 2019 and 2020. The other groups were more diverse. Some countries with the Continental European tradition (especially Belgium, but also Luxembourg, France, and Austria) had lower efficiency than others (i.e., Germany, the Netherlands and Slovenia). Within the South

European tradition, Italy had lower efficiency than the other countries (Greece, Portugal, Spain and Cyprus). Of the countries with the Scandinavian tradition, Finland and Denmark had lower efficiency than Sweden and Estonia. Therefore, the results did not corroborate research question RQ2 that there is a similarity in the efficiency of LMP expenditure in terms of the public administration tradition.

Table 2. A comparison of EU countries by the efficiency of public expenditure on LMP and public administration tradition in 2019 and 2020

Tradition of Public Administration	Efficiency 2019	Average 2019	Efficiency 2020	Average 2020
Anglo-Saxon tradition	IE (0.9973)	0.9973	IE (1)	1
Continental European tradition	AT (0.5085) FR (0.6372) DE (1) BE (0.4492) LU (0.5480) NL (0.8794) SI (0.8829)	0.7007	AT (0.5655) FR (0.6701) DE (1) BE (0.5564) LU (0.6143) NL (1) SI (1)	0.7723
Mediterranean/South European tradition	EL (1) IT (0.7765) PT (1) ES (1) CY (1)	0.9553	EL (1) IT (0.7245) PT (1) ES (0.8994) CY (1)	0.9248
Scandinavian tradition	DK (0.7482) FI (0.6346) SE (1) EE (1)	0.8457	DK (0.7250) FI (0.6545) SE (1) EE (1)	0.8449
Eastern European tradition	CZ (1) HU (0.9723) SK (0.8607) PL (1) LT (1) LV (1)	0.9722	CZ (1) HU (1) SK (1) PL (1) LT (1) LV (1)	1
South-Eastern tradition	BG (1) RO (1) HR (0.9110)	0.9703	BG (1) RO (1) HR (0.9984)	0.9995

Source: own study based on Halaskova, Halaskova, and Prokop (2018).

In 2019, the highest efficiency of LMP expenditure was found in Ireland (which represents the Anglo-Saxon tradition), as well as countries with the Eastern European and South-Eastern traditions. The lowest efficiency was achieved by countries with the Continental European and Scandinavian traditions.

In 2020, full efficiency was observed in Ireland (Anglo-Saxon tradition) and countries with the Eastern-European tradition. High efficiency was also reported for countries that followed the South-Eastern tradition, due to the improved efficiency of Croatia. A low level of efficiency was noticed for countries with the Continental European tradition, mainly due to Belgium and Austria's poor scores.

In 2020, during the lockdown caused by the COVID–19 pandemic, most groups of countries improved their scores on the efficiency of public expenditure on LMP. The exceptions were countries with the South European tradition and the Scandinavian tradition, where the measures of efficiency decreased slightly.

Discussion

Kluve and Schmidt developed a macro perspective of cross-country comparison of labor market policies, focusing on the effectiveness of European active labor market programs (Kluve 2010). The approach was later popularized in the literature and social policy practice. However, although the macro perspective of the efficiency approach in terms of the LMP is not very complex, it is not very popular in the literature, and is mainly used in regression analysis. The results demonstrate that unemployment is positively associated with generous unemployment benefits, a high tax wedge, and high union coverage. It is negatively associated with active labor market policies (ALMPs) and highly co-ordinated bargaining (Arpaia and Mourre 2009).

Mourre (2006) focused on the impact of labor market institutions on employment growth. He claimed relevant institutional factors likely to contribute to rising aggregate employment in the euro area include strong development of part-time jobs, lower labor tax rates and, more tentatively, less stringent employment protection legislation, as well as greater subsidies to private employment.

Fialová and Schneider (2008) confirmed that high taxes increase unemployment, while active labor market policies tend to reduce it in the EU. More stringent employment protection and higher taxes reduce the participation rate and the employment rate. Moreover, there seems to be a difference in the institutional effects between the "old" and "new" EU member states.

The World Economic Forum assesses macro labor market efficiency using ten indicators, which include cooperation in labor–employer relations, flexibility of wage determination, hiring and firing practices, redundancy costs (weeks of salary), the effect of taxation on incentives to work, pay and productivity, reliance on professional management, country capacity to retain talent, country capacity to attract talent, and female participation in the labor force (ratio to men) (Schwab and Xavier 2017).

The literature contains examples of research on the efficiency of the LMP using the non-parametric DEA method. It is often used to analyze the efficiency of public institutions (Cooper, Seiford, and Tone 2007; Behrenz, Delander, and Månsson 2013). However, the use of DEA for LMP is connected with micro- or mezzo-dimensions; it is not commonly used on the macro-scale. The efficiency analysis is used to evaluate public employment services (PES) (Rollnik-Sadowska 2019; Cichowicz et al. 2021).

Conclusion

The literature emphasizes the significant importance of identifying general principles to achieve efficient policy design at both micro- and macro-levels (Arpaia and Mourre 2009). The efficiency approach for evaluating LMP on a macro-scale is not popular in the literature, and the effectiveness approach is used instead. However, the effectiveness approach, represented by labor market indicator analysis, identifies only the outcomes of the LMP policy. It does not include the expenditure required for countries to conduct the policy. The effectiveness approach also does not make it possible to include environmental variables, which have an influence on achieving the LMP outputs while disposing of a certain level of inputs. Based on the effectiveness approach, Southern countries achieved the worst results. This is in contrast to the efficiency approach using DEA, where countries such as Portugal and Greece achieved full efficiency for both 2019 and 2020. Moreover, in Greece – in terms of the effectiveness approach – the labor market situation is worse than in Italy or Spain, which is different when the efficiency approach is included, allowing Greece to achieve better results than its neighbors.

The efficiency approach of LMP for 2019 and 2020 indicates that Central and Eastern European countries, such as Czechia, Poland, Romania, Bulgaria, Lithuania, Estonia, and Latvia, find themselves in a very good situation. Full efficiency was also achieved by Cyprus, Malta, Sweden, and Germany. The worst situation was observed in Belgium.

Countries that follow the Eastern European tradition (Czechia, Hungary, Slovakia, Poland, Lithuania, Latvia) and the South-Eastern tradition (Bulgaria, Romania and Croatia) achieved similar levels of efficiency of LMP in both 2019 and 2020. The other groups of public administration traditions were more diverse.

During the COVID–19 pandemic, most of the groups of countries improved their scores on the efficiency of public expenditure on LMP. The exceptions were groups of countries with the South European tradition and the Scandinavian tradition, where the measure of efficiency decreased slightly. This may prove the effectiveness of the implemented public policy to counteract the negative effects of COVID–19 on the labor market.

The added value of this paper comes from the demonstration that the proposed methodology, using the DEA method, can be used to measure LMP efficiency at the micro- and mezzo- levels and to conduct cross-country comparisons. A limitation of the study is that for efficiency evaluation, only two indicators – labor demand determinants, such as job vacancy rate and GDP per capita – were included as environmental variables. The literature also mentions other institutions that can influence the transformation of labor market inputs into outputs. They include unemployment benefits (both in terms of levels and duration) and Employment Protection Legislation (EPL), which protects the labor force from income volatility (Bertola 2004; Bertola and Keoniger 2004). Some scholars have noted difficulties using standard DEA models in the presence of input ratios and/or output ratios, which can also be treated as a limitation (Emrouznejad and Amin 2009). Additionally, econometric estimations that use macro indicators of labor market institutions tend not to be robust, as there is a degree of measurement error in the variables usually available to proxy policy-induced changes. Furthermore, different specifications and methodologies are employed among countries, further complicating the analysis (Arpaia and Mourre 2009).

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Efektywność polityk rynku pracy w krajach UE

Celem niniejszego artykułu jest zbadanie efektywności sektora publicznego w zakresie polityki rynku pracy w krajach UE. Dokonano kompleksowej oceny usług publicznych związanych z polityką rynku pracy z punktu widzenia efektywności wydatkowania środków publicznych na ten cel. Punktem zwrotnym dla europejskiego rynku pracy było wprowadzenie lockdownu w 2020 roku w związku z pandemią COVID–19. Dlatego też oceny efektywności rynków pracy UE dokonano

przed i podczas pandemii oraz ustalono, w jakim stopniu wielkość usług publicznych (ich alokacje finansowe) wpływają na wybrane wskaźniki rynku pracy.
Do oceny efektywności krajów UE w latach 2019 i 2020 wykorzystano metodę Data Envelopment Analysis (DEA). W badaniu zastosowano model BCC (Banker, Charnes, Cooper). Ponadto wybrano zorientowany na wyniki model BCC, który wydaje się dostosowany do specyfiki polityki rynku pracy. Wykorzystano program Microsoft Excel Solver, służący do opracowywania liniowych modeli optymalizacyjnych. Efektywność wydatków publicznych oceniono na podstawie danych z bazy Eurostat. Do analizy wykorzystano łącznie siedem zmiennych, w tym pięć określających nakłady (wydatki sektora publicznego na usługi rynku pracy według wybranej funkcji oraz dwie zmienne określające nakłady niekontrolowane reprezentowane przez wskaźnik wolnych miejsc pracy i PKB *per capita*), a także dwie zmienne wskazujące na wyniki w postaci wybranych mierników rynku pracy (wskaźnik zatrudnienia i stopa bezrobocia – wskaźnik odwrócony). Porównanie przekrojowe przeprowadzono w dwóch wymiarach – wśród poszczególnych krajów UE oraz wśród grup krajów reprezentujących różne tradycje administracji publicznej (tradycja anglosaska, tradycja Europy kontynentalnej, tradycja Europy Południowej, tradycja skandynawska, tradycja Europy Wschodniej i tradycja Europy Południowo-Wschodniej).
Badanie wskazuje, że pomimo osiągania przez kraje Europy Południowej najgorszych mierników rynku pracy, w podejściu efektywnościowym z wykorzystaniem metody DEA takie kraje jak Portugalia i Grecja osiągnęły pełną efektywność zarówno w 2019, jak i 2020 roku. Podejście efektywnościowe polityki rynku pracy dla 2019 i 2020 roku wskazuje również na bardzo korzystną sytuację w przypadku krajów Europy Środkowo-Wschodniej. Pełną efektywność osiągnęły także Cypr, Malta, Szwecja i Niemcy. Najgorsza sytuacja pod względem efektywności polityki rynku pracy występuje w Belgii.
W trakcie pandemii większość analizowanych grup krajów poprawiła swoje wyniki w zakresie efektywności wydatków publicznych na politykę rynku pracy. Wyjątkiem były grupy krajów o tradycji Europy Południowej i skandynawskiej, gdzie miara efektywności nieznacznie spadła. Może to świadczyć o skuteczności prowadzonej polityki publicznej w zakresie zwalczania negatywnych skutków COVID–19 na rynku pracy.
Wartość dodaną tego artykułu stanowi zaproponowanie metodyki z wykorzystaniem metody DEA, która może być używana do pomiaru efektywności polityki rynku pracy nie tylko na poziomie mikro i mezo, ale także do porównań pomiędzy krajami.

Słowa kluczowe: efektywność, usługi publiczne, polityka rynku pracy, metoda DEA, kraje UE, tradycja administracji publicznej

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.16

Analysis of Climate Change Adaptation Policies in Asia

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Abstract

The article addresses the issue of adaptation policies by comparing two regions in Asia: Southeast Asia and Northeast Asia. The aim is to highlight the directions and the degree of progress of the policies implemented, as well as their determinants. The methodology included an analysis of bibliographic materials and available data. As a result, it was possible to establish that the scope of carrying out adaptation policies varies depending on the country, and it is not possible to speak of a common continental policy or even a common regional policy. The degree of a country's development determines the sophistication of the policy pursued.

Keywords: adaptation policy, climate change, Southeast Asia, Northeast Asia

JEL: O44, O57

Introduction

Progressive climate change has consequences for humans, economies, and the environment. Knowledge of the causes and consequences of climate change should result in concrete measures of adaptation on the one hand and mitigation on the other. Countries implement specific adaptation policies into the practice of socio-economic life. Due to a number of regionally determined factors, adaptation policies implemented by individual countries differ.

Received: 2.10.2022. Verified: 3.04.2023. Accepted: 2.02.2024

The literature addresses adaptation policies in Asia and the Pacific very broadly. Studies have investigated parts of regions (Agarwal et al. 2021), vulnerability to climate change (World Bank 2009, pp. 41–56), climate change, climate resilience, and water security (Sawhney and Perkins 2015, pp. 56–84), challenges, policy tools, programs and adaptation measures in different areas (Anbumozhi et al. 2012; McKinsey Global Institute 2020), the economic costs and benefits of unilateral and regional actions on climate change in Bangladesh, Bhutan, India, the Maldives, Nepal and Sri Lanka (Ahmed and Suphachol 2014), and the social aspects related to migration due to climate change (United Nations, Economic and Social Commission for Asia and the Pacific 2017). They have also investigated climate change adaptation assessment (USAID 2010) and good practices (Roome 2022). The articles deal with adaptation measures taken by individual countries, for example, South Korea, Singapore, China, Bangladesh, and India (Vachani and Usmani 2014). There are publications that deal with activities implemented in various sectors, most often in agriculture (Nor Diana et al. 2022), including the problem of crop insurance (Sawhney and Perkins 2015, pp. 36–55), but also in urban, energy, and transport sectors (World Bank 2009, pp. 153–184). There is also the comprehensive publication entitled "The Economics of Climate Change in the Asia-Pacific Region" by the United Nations, Economic and Social Commission for Asia and Pacific (2016).

The paper presents the results of analyzing adaptation policies implemented in Asia. To better understand the issue, Asia was divided into two regions, which were then compared with each other to find commonalities and differences. This also serves to ascertain whether, like Europe, we can speak of a common adaptive continental policy. The methodology includes analyzing bibliographic materials and available data.

Climate change in selected regions of the world

The first step in designing climate change adaptation measures is to identify the risks of climate change in a given region and the priority areas. Table 1 shows the main characteristics of selected regions of the world and the potential risks and consequences of progressive climate change.

Climate change will affect agriculture the most. Based on projections for the sector through 2050, there is a general trend of a northward shift in agricultural productivity. However, studies point to a 3% decline in the output of world agriculture by 2080, a decline that will be felt most in poor and developing countries. Thus, in China and Japan, for example, agricultural productivity is expected to decrease significantly due to lower profitability of wheat, rice and corn production. Meanwhile, in India, agricultural yields are expected to decrease 5.4%, while population density is increasing. This will significantly reduce food security and increase poverty

in the country (the percentage of extremely poor people will increase from 4 to 6%) (World Bank 2010, pp. 40–41).

Table 1. Threats and consequences of climate change by world region

Sub-Saharan Africa	East Asia and the Pacific	South Asia	East Europe and Central Asia	Latin America and the Caribbean	Middle East and North Africa
The region is prone to droughts and floods. Its economy depends on natural resources. Biomass provides 80% of energy. Agriculture accounts for 23% of GDP and employs 70% of residents. Poor infrastructure can hinder adaptation efforts. Problems: limited drinking water and malaria.	There is a large population living on the coast. The region's profitability depends heavily on agriculture. Problems: rapid urbanization and industrialization, environmental degradation, loss of marine resources (coral reefs). Expected changes: a more intense rainy season and the dry season extended by two months.	High levels of poverty, high population density, threat of lack of potable water supply, loss of ecosystems: melting glaciers, sea levels rising to flood levels, shrinking coastlines, loss of agriculture.	Ineffective environmental management (Russia) and poor state of infrastructure; low resilience to the impact of floods, storms and heat waves. Accelerated melting of Central Asian glaciers.	Very high threat to ecosystems, melting of tropical Andes glaciers, reduced drinking water supplies, warming and acidification of the oceans, threat to coral reefs, damage to the Gulf of Mexico, and a threat to the Amazon rainforest. Threats: more frequent and intense hurricanes.	The region most vulnerable to drinking water shortages (a 50% decline, even without climate change), a decline in agricultural profitability, threat to regional food security, high population density, resource scarcity, and socio-political conflicts.

Source: own work based on the World Bank (2010).

The main challenge for climate change prevention efforts is to reduce carbon emissions. The largest sources of CO_2 emissions are, in turn, energy production (26%), industry (19%), land use change and forestry (17%), agriculture (14%), transportation (13%), buildings (8%), and waste and wastewater management (2%) (World Bank 2010, pp. 190–196). What negatively impacts efforts to reduce emissions is the increasing wealth of societies. Higher incomes accelerate urbanization and the growth of the construction industry, increase consumption, and increase the number of travelers and the number of cars (abandonment of public transport), with increased transportation contributing to increased carbon dioxide emissions. Table 2 presents data on planned CO_2 reductions, the share of Renewable Energy Sources (RES), energy efficiency improvements and changes in the transport industry in selected countries. Table 3 shows the percentage distribution of carbon dioxide emissions by industry and income of countries.

Table 2. Planned preventive measures in selected countries

	U.S.	Canada	Australia	China	India	Mexico	Brazil
Planned reduction of CO_2	80% of 1990 levels by 2050.	20% of 2006 levels by 2020.	15% of 2006 levels by 2020.	Established a group of experts on climate protection and CO_2 emissions reduction, overseen by the prime minister.	National Action Plan on Climate Change – not to exceed emissions above the levels of developed countries.	50% of 2002 levels by 2050.	70% of 1990 levels by 2018.
Planned use of RES participation	25% by 2025	nd	nd	15% by 2020.	23 gigawatts by 2012.	8% by 2012.	10% by 2030.
Energy efficiency	nd	nd	nd	Reduce energy intensity by 20% from 2005 to 2100.	A reduction of 10 gigawatts by 2012.	nd	nd
Transport	Reduce fuel consumption by a gallon per 35 miles by 2016.	nd	nd	Achieve the goal of reducing fuel consumption by a gallon per 35 miles. Plans to be a leader in the use of electric vehicles and underground bulk transportation	Increased investment in public transport.	Increased investment in public transport	World leader in ethanol production.

Note: nd = no data.
Source: own work based on World Bank (2010, p. 192).

Table 3. CO_2 emissions by industry and country income (ppm part per million, based on World Bank classification)

	World	High-income countries	Middle-income countries	Low-income countries
Energy	26	36	26	5
Industry	19	17	16	7
Transport	13	23	7	4
Land management and forestry	17	–	23	50
Agriculture	14	8	14	20
waste management	3	–	–	–
Buildings	8	–	–	–
Others	–	18	14	14

Source: own work based on World Bank (2010, pp. 190–196).

For global warming to stop at 2˚C, a maximum CO_2 emission of 450 ppm is required. For this, action is needed to reduce emissions in power generation by 71%, construction by 41%, transportation by 30%, and industry by 21% (50% in total) by 2050 (World Bank 2010, p. 200). To achieve this, energy efficiency must be increased, and total energy demand must fall. To achieve this goal, reductions in oil and coal consumption, and increased use of RES and carbon detection and storage technologies are required. Unfortunately, these technologies are not without flaws and problems. In the case of wind, hydropower, and geothermal power, the main problem is the limited number of available sites. Biomass is limited by competition from agricultural and forestry production, while solar energy production is still expensive. Nuclear energy raises concerns about the development of the weapons market, waste management, and the danger from reactors. Carbon storage and storage technologies are in the testing stages of commercialization and may be limited by space availability and high costs. However, studies show that investing $1 in increasing energy efficiency avoids more than $2 in the cost of producing new energy and further promotes countries' development (World Bank 2010, p. 209). A summary of priority climate change prevention measures by country income level is shown in Table 4.

Table 4. Priority prevention activities by income

High-income countries	Middle-income countries	Low-income countries
– increase access to on-grid and off-grid energy, – increase energy efficiency and use of RES, – remove mines, – fuel subsidies.	– improve energy efficiency and use of RES, – adaptive urbanization orientation, – develop low-carbon urban transportation, – remove mines and reduce coal consumption, – fuel subsidies, – invest in R&D of new technologies.	– reduce the carbon footprint of single households, – lifestyle changes, – remove mines, – fuel subsidies, – invest in R&D of new technologies, – fund the transition away from coal energy in developing countries.

Source: own work based on World Bank (2010, p. 204).

Water management and drinking water shortages could be the biggest challenge posed by climate change, experts point out. Humidity around the world is increasing, higher temperatures will lead to evaporation and more frequent droughts, and there will be an increase in rainfall and rain-free periods. The solutions used so far may not be enough, and the pace of change will be too fast to find new solutions (this has occurred in Peru, where farmers have abandoned previously cultivated crops due to a lack of water). In the case of the water resource, as with food security, rising demand[1] meets falling supply, exacerbating the water deficit.

As the UN points out, a small number of countries have knowledge of the quantity and quality of the available water supply and estimates of how much water can be withdrawn without upsetting the environmental balance. This is due to the high complexity of monitoring the water resource and the lack of uniform international standards. Other problems include treating water as a public good with an infinite amount – there is a lack of standards for using the water resource and a lack of adequate regulations to enforce fees for the water resource used (e.g., in forestry). Many experts believe that the best solution for reducing the water deficit is appropriate technologies to increase water productivity (including groundwater, such as groundwater pumps and mulching) and enabling the use of rainwater (stormwater), seawater desalination, recycling, and water storage (World Bank 2010, p. 137).

Climate change also affects fisheries. Even without climate change, through overexploitation of marine ecosystems, it is estimated that productivity will decline by 25 to 30 percent, with no chance of returning to baseline levels. The worldwide cost of mismanaging marine ecosystem resources is estimated at about $50 billion a year. Fish and shellfish protein provides 8% of the world's animal protein needs. With the world's

1 A single person's daily consumption is 2 to 5 liters of water, with 2,000–5,000 liters of water used in food production.

population growing by about 78 million people per year, it makes it imperative that fish production should grow by about 2.2% a year, maintaining the current 29 kilograms per person per year (World Bank 2010, p. 157).

Experts stress that only a sustainable fishing policy can save the industry from a total loss of productivity. New coastal management solutions are needed (including reducing stress on marine ecosystems, such as coral reefs), the introduction of marine protected areas, fishing restrictions, coastal enforcement policies, fishing technology, and licensing. High hopes are pinned on aquaculture, or the raising, breeding, and cultivation of aquatic organisms (plants or animals). Such activities are carried out in either a controlled or specially selected aquatic environment. In 2006, it accounted for 46% of the world's fish supply, with an estimated 7% average annual growth. A major challenge for aquaculture is the quality of fish; in 2010, 40% of aquaculture depended on industrial feeds. The emphasis is on herbivorous or omnivorous cultures, as carnivorous ones are less efficient, e.g., 2.5–5 kilograms of wild fish are needed to produce a kilogram of salmon or shrimp. A major cost of aquaculture is the burden on the environment; by 2010, it was responsible for the loss of 20 to 50% of mangroves (World Bank 2010, p. 157)[2].

The global market will see a shortage of crops, rising food prices, and price volatility due to rising demand. There will also be more difficult growing conditions (higher costs associated with adaptation measures, such as the use of new technologies), declining water resources, and higher energy prices as a result of climate policy. Estimates indicate a 60–97% increase in the price of rice, corn, soybeans and wheat, and a 31–39% increase in the price of beef, pork, and poultry between 2000 and 2050. These increases will be felt most severely in poor regions, where the population spends 80% of its income on food purchases. Despite differences in estimates of the percentage changes in prices, there is a consensus on the threat to global food security and an increase in the problem of hunger, primarily in South Asia and Africa (World Bank 2010, p. 168).

A major threat posed by climate change is the spread of diseases and more cases of known diseases, e.g., malaria. It kills nearly one million people a year, and by 2050 will increase by an estimated 14% in Africa alone and globally by 30 to 60% by 2070. New strains will emerge, and with them, there will be problems with treatment due to the lack of adequate drugs. The problem is particularly acute in poor countries. It is estimated that the number of deaths due to climate impacts will increase by 150,000 per year and more, and indirect effects, such as the spread of diseases (mainly those related to diarrhea disrupting cognitive function and learning ability, especially among children), will negatively affect productivity in the long term (losses in productivity).

2 Mangroves, mangrove forests – evergreen, pioneer plant formation of sea coasts in almost the entire intertropical zone. They generally occur in the intertidal area and are therefore sometimes called tidal forests. However, this term is not accurate, as the tides are not always clear in the areas where mangroves occur.

The spread of diseases requires the state to take appropriate, often costly, measures, i.e., early epidemic containment systems, adequate medical security, investment in research, designing diagnostic tools, developing information (communication) and monitoring techniques, developing sanitation and water management systems, preventing the breeding of disease-spreading insects, and providing training systems for health care personnel. Only well-functioning adaptation systems, set up by the government and supported by the private sector, can reduce deaths and keep losses to a minimum (World Bank 2010, pp. 90–92).

Another increasing problem is heatwaves and the formation of "heat islands" in cities, where the perceptible temperature is 3.5–4.5°C higher. The seriousness of the problem is underscored by data on the 2003 heat wave, which caused a total of 70,000 deaths in the following countries: Italy (20,089 deaths), France (19,490), Spain (15,090), Germany (9255), Portugal (2696), Belgium (1175), Switzerland (1039), the Netherlands (965), Croatia (788), England (301), Slovenia (289), and Luxembourg (166) (World Bank 2010, pp. 93–96).

Identifying climate change adaptation actions in Asia

In the Asia-Pacific region, the consequences of climate change are being felt by nations and communities in many different sectors. Rising sea levels, intensifying winters, long droughts, and increased risk of flooding are just some of the impacts of climate change in the region. Faced with a changing environmental context, governments are struggling to achieve and maintain water, food, and energy security, while the continent's people are trying to adapt to the new climate reality. As the struggle for access to natural resources intensifies, the need for transboundary and regional resource management is also expected to increase.

Efforts to adapt to progressive climate change on the continent are regionally diverse. Many stakeholders, such as governments, the public, and the international community, are engaged in multi-level adaptation activities (at international, national, and local levels). Through cross-regional cooperation, the Asia-Pacific Adaptation Network (APAN) conducts knowledge management activities and supports governments and other organizations that work on climate change adaptation. By sharing knowledge and expertise from across the region, APAN seeks to increase the decision-makers' access to technologies and funding, and design and implement adaptation initiatives (Sawhney and Perkins 2015, pp. 2–6).

The first adaptation program in the Pacific region was Capacity Building for the Development of Adaptation Measures in Pacific Island Countries (CBDAMPIC). It addressed the long-term risks of climate change in development and resource management planning, and improved adaptive capacity and livelihoods through integration. The project included the following three stages of adaptation: Stage I – Planning,

researching the possible impacts of climate change to identify particularly vulnerable countries or regions and policy options for adaptation and appropriate capacity building; Stage II – Actions that can be taken to prepare for adaptation as envisioned in Stage I ; Stage III – Activities to facilitate appropriate adaptation, including insurance and other adaptation measures envisioned in Stage I . Most of the climate change projects introduced in the Pacific fall into the Stage I and II categories, while the CBDAMPIC project is the first step to Stage III (Nakalevu 2016, pp. 44–51).

The CBDAMPIC project recommended a climate change adaptation approach based on two "downstream" and "upstream" levels and "learning by doing." The project promotes adaptation activities that empower residents to initiate action in response to the adverse effects of climate change using a participatory approach. While the global and regional community provides solutions to common problems, local solutions should be the basis for long-term climate change adaptation. The project was piloted in 16 communities in four countries (the Cook Islands, Fiji, Samoa, and Vanuatu), and important lessons were learned for future adaptation work (Nakalevu 2016, pp. 44–51).

Pacific Adaptation to Climate Change (PACC), on the other hand, is a regional project involving 14 Pacific countries. PACC's goal is to "enhance the capacity of participating countries to adapt to climate change, in selected key development sectors." The project's outputs include increased adaptive capacity in key economic sectors such as the coastal sector (in the Cook Islands, Micronesia, Samoa, and Vanuatu), agriculture and food, the security sector (in Fiji, Palau, Papua New Guinea, and the Solomon Islands), and the water sector (in the Marshall Islands, Nauru, Niue, Tokelau, Tonga and Tuvalu). The project has helped integrate climate change adaptation measures into national policies and programs in the economic sectors above. It also promoted regional cooperation among participating countries, sharing experiences, innovating and including adaptation measures in national development goals, plans, strategies, and programs (Nakalevu 2016, pp. 44–51).

In Central Asia, the Central Asia Regional Economic Cooperation (CAREC) has produced a report entitled "Adapting Technology to the Needs of Central Asia's Water Industry and Agriculture." The report recommends the following measures (including disaster preparedness): afforestation and forest restoration (preservation of ecosystems), using irrigation technologies in agriculture, constructing necessary infrastructure for access to groundwater, reconstructing irrigation systems, water resources (supply and storage), supporting breeding programs to develop drought-resistant crop varieties, introducing advanced agricultural technologies (soil and moisture conservation technologies), crop diversification and rotation, developing modern systems for early warning and the prevention of natural anomalies (including effective weather forecasting methods), and breeding programs to diversify crop and livestock varieties and develop varieties and species resistant to expected changes in climatic conditions (Regional Environmental Center for Central Asia (CAREC) 2012).

The United Nations Environment Programme (UNEP) launched the Asia-Pacific Adaptation Network, which was followed by the Global Adaptation Network. The task of these networks is to strengthen national scientific and policy dialogues. The networks bring together universities and institutions to address the need for better interaction and communication of policy and science on climate change issues, particularly adaptation (http).

As presented in the Climate Change Action (CCA) conducted for South Asia (countries such as India, Bangladesh, Afghanistan, the Maldives, Pakistan, and Nepal), the main gaps in the adaptation process relate to the fact that the national development strategies of South Asian countries continue to focus on GDP growth rates. This is problematic for two reasons. First, it is based on the assumption that economic growth will automatically result in more jobs, thereby increasing prosperity and reducing vulnerability. However, there is no empirical support for this assumption for this region. Second, the focus on GDP growth ignores the important determinant of climate change mitigation of achieving production increases in a sustainable and climate-resilient manner (Mehta and Vashist 2015, pp. 7–17).

In the context of achieving greater overall efficiency, all South Asian countries' national plans and strategies have identified better governance as a priority, as well as the more efficient management of natural resources. Three main aspects have been identified for improvement. First, there should be increased awareness of the need for adaptation activities by administrative officials and governments at all levels with tangible results in concrete adaptation plans and their implementation. The second aspect is the continuous monitoring and auditing of these programs. Social audits, in particular, are a very useful tool for assessing program effectiveness, as they directly involve beneficiaries in the auditing and monitoring processes. Third, improved coordination of institutional climate change cooperation is required within and between countries (Mehta and Vashist 2015, pp. 7–17). As a lack of sources of funding for adaptation activities is a major problem in South Asian countries, Mehta and Vashist (2015, pp. 7–17) pointed out that it is necessary to raise funds both domestically and from international organizations.

In the South Asian region, there is a positive trend of small-scale climate change adaptation initiatives undertaken by local communities or NGOs. Regionally, these initiatives have not produced tangible results, but they provide a good basis for further action at both the national and regional levels. An issue that requires rapid intervention is the existing water-sharing agreements between various countries in South Asia, which ignore the issue of climate change (Mehta and Vashist 2015, pp. 7–17).

In the South Asia region, it is necessary to shift the focus of adaptation efforts from disaster response to effective weather risk management, including a focus on preparedness and countermeasures, improving flood and drought forecasting, establishing early warning systems, and improving information flow. It is recommended that comprehensive action plans include technical plans and guidelines, disaster preparedness policies

with allocated resources, decentralized coordination mechanisms, implementation of gender policies, and access for women and children to all interventions to achieve integrated flood and drought management (Mehta and Vashist 2015, pp. 7–17).

Despite the vast water resources available, the lack of agreement among states in the region generates conflicts. Conducting integrated policies at the state level is an important factor that influences adaptation initiatives at the regional level (Mehta and Vashist 2015, pp. 7–17). The jointly adopted "Integrated water resources management" (IWRM) initiative, and acts and plans in individual countries (e.g., Bangladesh – National Water Policy 1999 and National Water Management Plan 2004; Bhutan – Water Act 2011; India – Draft National Water Policy 2012; Nepal – National Water Plan 2002), have so far failed to produce tangible results. The main reason is the lack of institutional establishment or policy implementation mechanisms. No country in the region has a mechanism or institutional framework for allocating or distributing resources. Institution building is especially needed at the community level. The regulatory framework needs to be revised in light of integrated water resources management at the river basin level, incorporating an ecosystem approach. Estimating the economic value of water should take into account decisions regarding the allocation of water resources and the pricing of water services (Mehta and Vashist 2015, pp. 7–17).

Southeast Asia

Southeast Asian countries increasingly act towards addressing climate change. All countries in the region have adopted the UNFCCC (United Nations Framework Convention on Climate Change), signifying their recognition of "common but differentiated responsibilities" and a commitment to responding to the challenges of climate change in terms of mitigation and adaptation. Many of these countries have formal institutions responsible for climate change, which were established either as independent entities that report directly to the head of state (president, prime minister) or as special divisions within the Ministry of the Environment (Diomampo 2015, pp. 181–221).

Most countries in the region are integrating climate change into their development plans, as well as developing their climate change action plans. In Indonesia and the Philippines, in addition to general climate change plans, they have developed climate change strategies/detail plans – National Climate Change Action (CCA) plans. However, there are also some that have not yet developed CCA plans, let alone implemented them. For example, Brunei and Myanmar must first conduct a vulnerability/impact assessment to formulate their climate change plans/strategies (Diomampo 2015, pp. 181–221).

The region's priority CCA sectors are agriculture, water resources, coastal/sea resources, forestry, biodiversity, and health. The three most common priorities for Southeast

Asian countries (with the exception of Brunei) are cross-sectoral approaches to climate change, water resources, and health. Agriculture and water resources remain important sectors for both livelihoods and food security, thus becoming a CCA priority for most countries in the region. This is especially true for countries with a high percentage (more than 50 percent) of their labor force engaged in agricultural activities, such as Timor Leste, Cambodia, Laos and Vietnam. As expected, the CCA priority sectors reflect the characteristics and gaps in each country. For example, agriculture and forestry are not priority sectors for Singapore, a highly urbanized country. Instead, the Urban Heat Island effect was identified as a priority due to its high population density and energy-intensive manufacturing-based economy (Table 5) (Diomampo 2015, pp. 181–221).

Table 5. Southeast Asia's key sectors of adaptation

Country	Key sectors for adaptation
Brunei	Forestry and biodiversity
Indonesia	Agriculture, water management, coastal resources, forestry and biodiversity, health care
Lao PDR	Agriculture, water management, coastal resources, forestry and biodiversity, health care
Malaysia	Agriculture, water management, coastal resources, forestry and biodiversity, health care, energy, industry and transport
Myanmar	Agriculture, water management, coastal resources, forestry and biodiversity, health care, energy, industry and transportation
Philippines	Agriculture, water management, coastal resources, forestry and biodiversity, health care
Singapore	Water management, coastal resources, health care, Urban heat island
Thailand	Agriculture, water management, coastal resources, forestry and biodiversity, health care
Timor Leste	Agriculture, water management, coastal resources, forestry and biodiversity, health care, energy, industry and transportation, infrastructure
Vietnam	Agriculture, water management, coastal resources, forestry and biodiversity, health care, energy, industry and transportation

Source: own work based on Diomampo (2015, pp. 181–221).

In almost all key sectors for CCAs in each country, activities are assumed to improve infrastructure. Other common features of the plans/strategies are the assumption of changing practices, developing planning systems, raising awareness and establishing monitoring/warning systems (Diomampo 2015, pp. 181–221).

One of Southeast Asia's key industries is agriculture, so available studies (e.g., APAN and The South-East Asian Regional Center for Graduate Study and Research in Agriculture –SEARCA) indicate that the region's climate change adaptation efforts should focus specifically on agriculture. To date, climate change adaptation efforts in the agricultural

sector in Southeast Asia have been sporadic and inconsistent. The adaptation action initiatives that do occur are mainly on small farms, without external support (which may provide a basis for using the concept of climate-smart agriculture, CSA, in this region) (APAN-SEARCA 2013).

The challenge for the region is for the government to put in place the correct policy and infrastructure mechanisms in line with the principles of sustainable agriculture. In addition, effective adaptation measures for the region should be based on close cooperation between local governments and private organizations to share costs and improve implementation and management. Examples of good practices of adaptation measures for this region of Asia include the introduction of decision-support systems for farmers, investment in agriculture, financial incentives for farmers (e.g., crop insurance), raising farmers' awareness of climate impacts and hedging options, and the free flow of technological knowledge to enable the introduction of sound agricultural practices (Ancog and Ticsay 2015, pp. 18–31).

Table 6. Adaptation policies of Southeast Asian countries

Country	Adaptation policy	Institution responsible	Regional distribution of funds for adaptation measures
Brunei	None	None	0%
Cambodia	Cambodia's Climate Change Strategic Plan 2014–2023 (The National Climate Change Framework)	The Climate Change Department, which is under the Ministry of the Environment	31%
Indonesia	National Climate Change Action Plan in preparation	Indonesia's National Council on Climate Change, Geophysical and Climatological Agency (under the Ministry of Environment)	14%
Lao PDR	*The National Climate Change Strategy*	Lack of a single responsible institution, all ministries are required to take climate change into account in their activities	4%
Malaysia	Climate change adaptation plan project phase	Unable to identify the institution responsible	0%
Myanmar	Climate change adaptation plan project phase	Unable to identify the institution responsible	1%
Philippines	*The National Climate Change Action Plan*, NCCAP, 2011–2028	*The Climate Change Commission*	26%
Singapore	*The National Climate Change Strategy 2013*	*The National Climate Change Secretariat*	0%

Country	Adaptation policy	Institution responsible	Regional distribution of funds for adaptation measures
Thailand	*The Thailand Climate Change Master Plan* (2012–2050)	Unable to identify the institution responsible	1%
Timor Leste	Climate change adaptation plan project phase	Unable to identify the institution responsible	2%
Vietnam	National Climate Change Action Plan in preparation	*The Department of Meteorology, Hydrology and Climate Change*	21%

Source: own work based on Diomampo (2015, pp. 181–221).

In assessing the sophistication of climate change adaptation efforts in the Southeast Asian region, it can be seen that while there are countries with high levels of sophistication, there are still countries such as Timor Leste, Myanmar and Brunei, for example, which are in the preliminary stages of implementation. These countries still lack institutional and legal frameworks and even have a limited assessment of climate change impacts. The level of implementation in Brunei, despite its financial resources, is much lower than in other countries in the region. Countries with relatively more experience in implementing CCA initiatives have the right institutions, plans and policies in place. A problem in the region is a lack of coordination and integration, which is important given that climate change issues affect many sectors and involve different levels of government. Other challenges include fragmented or sometimes overlapping responsibilities between different institutions, such as the environment ministry and autonomous climate change offices. In addition, most countries lack sufficient knowledge and skills (e.g., indicator development, assessment), technology, and human, financial and methodological resources.

Despite the existence of CCA initiatives at the local level, it is important to further increase education, capacity building, and the involvement of local governments and the public in climate change issues. It is also important to improve coordination between national and local institutions. Other problems identified include unrealistic action plans, incomplete or inconsistent policies/legal documents (e.g., lack of risk assessments), low awareness, capacity and expertise in CCA monitoring from central to local levels, a lack of availability or lack of baseline data, a lack of vulnerability assessment studies, political barriers (e.g., changing views of politicians or policymakers), and difficulties in measuring the effectiveness of ongoing activities due to varying definitions, and uncertainty of climate change and future developments (Diomampo 2015, pp. 181–221).

Four countries account for 92 percent of CCA funding in the region. The majority of adaptation funding in the region comes from public sources, so it is understandable that systems for monitoring adaptation activities in countries that receive more funding are better developed, matching the reporting requirements of funding agencies (Diomampo 2015, pp. 181–221).

Northeast Asia (China, Japan, Korea, Mongolia)

China, Japan and Korea play an important role in the region's economy, as well as the world's. China, due to the vastness and diversity of its terrain, is characterized by varying impacts of climate change. The Tibetan Plateau is experiencing the consequences of climate change in the form of changes in river flows and melting glaciers. Conversely, northwestern China is threatened by worsening desertification caused by lower rainfall and higher evaporation rates. Northern and northeastern China are affected by water shortages, while parts of the east and southeast are affected by frequent storms and long-term flooding. Since 2012, China has suffered from more frequent extreme weather, with the National Development and Reform Commission (NDRC) pointing out that many areas in southern China have experienced very high temperatures, flooding, and mountainous landslides and mudslides (National Development and Reform Commission (NDRC) People's Republic of China 2013).

In Japan, an archipelago of islands, temperatures have risen by 1.15˚C in the last century. The most serious consequences of climate change are the increasingly severe effects of heat on society, declining agricultural production, health problems, and weather anomalies (Japanise Ministry of the Environment 2009).

Korea has seen a temperature rise of 1.7˚C and a sea level rise of about 22 centimeters over the past 100 years. The negative dimensions of climate change in the region are mainly heat waves, which pose a threat to public health, and extreme weather events (The Government of the Republic of Korea 2003).

Mongolia's average temperature has increased by 1.9˚C since the 1940s. A major problem for Mongolian agriculture is dwindling water resources, especially in naturally dry regions. A consequence of climate change in this area is extreme weather phenomena, which worsen the country's already difficult economic and social situation. Intense snowfall, dust storms, hailstorms, and floods are common occurrences in the country. Every year, about 2.4% of the animal population dies as a result of severe weather conditions (Dagvadorj et al. 2009). Disasters, called "dzud," have caused massive loss of livestock and direct damage to nomads and their way of life (Yan, Oba, and Balt 2015, pp. 199–205).

On the path of rapid urbanization and economic development, China is trying to find a balance point for economic growth and reduce the negative effects of climate change. In China, the plan for climate change adaptation is to integrate the problem of climate change into socio-economic processes, enhance the adaptive capacity of key sectors of the economy and society, and introduce a Chinese development plan that considers the ability to cope with the negative consequences of climate change and is based on the paradigm of sustainable development. The goal of adaptation activities is to improve the ability to reduce the negative consequences of disasters, increase irrigation efficiency, and recover 50% of desert land. Achieving these goals should take into account

the balance of global and national development needs. There should also be simultaneous prevention and adaptation activities, increased technological and institutional innovation, and cooperation between society and government (National Development and Reform Commission (NDRC) People's Republic of China 2013).

Japan's adaptation plan aims to make the country more resilient to extreme weather events. The main goals are to avoid or adapt to risks, reduce negative impacts, and take advantage of benefits. The goals will be achieved with all possible mitigation and adaptation measures (Basic Act for National Resilience 2013).

Korea aims to create a climate-resilient society and support green growth. The main goals are to be ranked seventh on the list of green economy leaders by 2020, and fifth by 2050. To this end, the National Climate Change Action Plan (NCCAMP) was enacted, and the National Adaptation Committee (NGAC) and the National Climate Adaptation Center (KACCC) were established (The Government of the Republic of Korea 2012).

Mongolia's stated goal is to create a sustainable environment for development through its ability to adapt to climate change. This will be done by promoting its ability to adapt to climate change, reducing risks, and facilitating adaptation at the local community level. These activities will be possible by analyzing the impact vulnerability of the environment and economic sectors to climate change and adapting socio-economic development policies to the results (relevant legal acts required) (Ministry of Environment and Green Development 2013).

All the countries in question are considering climate change mitigation and adaptation to create a favorable relationship with the environment and social development that is consistent with sustainable development. The key sectors for adaptation activities are presented in Table 7.

Table 7. Northeast Asia's key sectors for adaptation

Country	Key sectors
China	Agriculture and forestry, soil desertification, water management, coastal protection, biodiversity, health care, energy production, critical infrastructure, monitoring and warning systems.
Japan	Agriculture and forestry, water management, coastal protection, health care, critical infrastructure, community.
Korea	Agriculture and forestry, water management, coastal protection, health care, energy production, critical infrastructure, monitoring and warning, education.
Mongolia	Agriculture, cattle ranching, soil desertification water management, biodiversity, critical infrastructure.

Source: own work based on Japanise Ministry of the Environment (2010; 2012); The Government of the Republic of Korea (2012); National Development and Reform Commission (NDRC) People's Republic of China (2013); Mongolia's Initial National Communication (n.d.).

Table 8 presents the range of adaptation policies of Northeast Asian countries.

Table 8. Northeast Asia's adaptation policies

Country	Adaptation policy	Responsible institution	Supportive institutions
China	No unified regulations on climate change adaptation measures. They are not included in legislation or regulations. Developed National Adaptation Strategy and Adaptation Action Plan.	*National Development and Reform Commission*, NDRC	*National Leading Group to Address Climate Change*, NLGACC
Japan	Law to promote the prevention of global warming (1998, amended 2002). In 2012, a law to combat global warming was rejected.	Ministry of Environment	*The Climate Change Commission*
Korea	National Climate Change Adaptation Plan (2009–2030). Law on low-carbon, green growth (2009–2050). National Strategic Plan for Adaptation to Climatic Change (2011–2015).	Ministry of Environment	*National Government Adaptation Committee*, NGAC
Mongolia	Climate change adaptation measures are not included in laws and statutes (only a few mentions in sectoral regulations, without implementation). National Adaptation Strategy and Adaptation Action Plan developed.	Ministry of Environment and Green Development	*The National Agency for Meteorology, Hydrology and Environment Monitoring*, NAMHEM

Source: own work based on Barbi (2016, pp. 324–339); National Development and Reform Commission (NDRC) People's Republic of China (n.d.); Ministry of Environment (n.d.); Ministry of the Environment, Government of Japan (n.d.); *Climate Change Adaptation…* (n.d.); World Meteorological Organization (n.d.).

Table 9 summarizes the above analysis of adaptation policies in the Southeast and Northeast Asia regions. It shows a feature that is common to all countries on the continent – recognizing the problem of climate change and the urgent need for adaptation policies, especially in agriculture and forestry, water management, and coastal protection. All the countries analyzed indicate the importance of raising public awareness of adaptation. However, the scope of carrying out adaptation policies varies from country to country, and it is not possible to speak of a common continental policy, or even a common regional policy.

Table 9. Comparison of selected CCA indicators by region

Indicator	Southeast Asia	Northeast Asia
CCA common priority sectors	Agriculture, water resources, coastal/sea resources, forestry, biodiversity and health	Agriculture and forestry, water management, coastal protection, critical infrastructure
CCA joint priority activities	Cross-sectoral approach to climate change, water resources and health	increase public awareness of CCA
CCA consistency across countries	Consistency is about recognizing the need to develop planning systems, raise awareness, and create monitoring/warning systems	
CCA's main concern	Lack of coordination and integration of individual policies, fragmented or sometimes overlapping responsibilities between institutions, lack of sufficient knowledge and skills (e.g., indicator development, evaluation), technology, and human, financial and methodological resources	Lack of cooperation within the region, mainly in terms of information/knowledge flow and facilitating learning processes
CCA policy advancement	There are countries with high levels of progress; still, countries such as Timor Leste, Myanmar and Brunei are in the preliminary stages of implementation. They still lack institutional and legal frameworks, and even have limited climate change impact assessments	The sophistication of the CCA is closely related to a country's stage of development: Japan (top development country) – the adaptation vision is largely focused on maintaining advanced socio-economic development that is conducive to change. Korea (highly developed country) – the vision of adaptation is to strengthen the economy and maintain a state of advanced development in a sustainable manner until 2050. China (developing country) – adaptation efforts are part of a national strategy to achieve developed country status by 2050. Mongolia (least developed country in the region) – adaptation vision is set to achieve the Millennium Development Goals by 2050

Source: own work.

Conclusion

An important conclusion drawn from the analysis of the results is that a country's development level determines the sophistication of its CCA policy. Therefore, it can be concluded that adaptation solutions are sought only when other problems have already been solved and when society reaches a satisfactory level of development

followed by a sufficient degree of prosperity. At this point, it is worth mentioning the other side of the issue – one of the main effects of economic development is progressive climate change with its consequences. So, we pose a question for further research and consideration: Shouldn't a climate change adaptation policy be an integral part of the development policy of each country/region/continent, so that it goes hand in hand with that policy, rather than being a necessity? It may be too late to introduce such a scheme of action, but an affirmative answer indicates the need to work intensively on advancing adaptation policies to make the most of the negative consequences of the economic development to which humanity so doggedly aspires.

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Analiza polityki adaptacyjnej do zmiany klimatu w Azji

Artykuł podejmuje zagadnienie polityk adaptacyjnych w oparciu o porównanie dwóch regionów Azji: Azji Południowo-Wschodniej oraz Azji Północno-Wschodniej. Celem jest zwrócenie uwagi na kierunki, stopień zaawansowania realizowanych polityk, a także ich uwarunkowań. Zastosowano metodę analizy materiałów bibliograficznych oraz dostępnych danych. W wyniku przeprowadzonej analizy udało się ustalić, że zakres prowadzenia polityki adaptacyjnej jest różny w zależności od analizowanego regionu, nie można mówić tutaj o wspólnej polityce kontynentu, a nawet wspólnej polityce regionalnej. Stopień rozwoju danego kraju warunkuje stopień zaawansowanie prowadzonej polityki.

Słowa kluczowe: polityka adaptacyjna, zmiany klimatu, Azja Północno-Wschodnia, Azja Południowo-Wschodnia

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.17

An Assessment of Financial Monitoring Systems: Ukrainian and Foreign Experience

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Abstract

The study characterizes financial monitoring as part of the system for preventing and counteracting the legalization of income and the financing of terrorism. The purpose of the research is to study the experience of how national financial monitoring systems function (in the UK, USA, China, Georgia, Moldova, Pakistan, Poland and Ukraine) in order to determine development directions and identify implementation opportunities in domestic practice. The research methods include induction, analysis and synthesis, static, comparative and graphical methods. The research methodology is based on the analysis of official static data and information materials from the official websites of international organizations and competent national authorities.

Received: 12.07.2023. Verified: 3.11.2023. Accepted: 25.03.2024

The article analyzes the statistical data of the state bodies of Ukraine in terms of their activities in the field of combating the financing of terrorism. It also constructs profiles to assess the effectiveness of anti-money laundering systems as well as the handling of proceeds of crime and financing of terrorism in a number of countries, following the FATF (Financial Action Task Force) methodology. The results demonstrate that all national financial monitoring systems must comply with the requirements of the FATF. However, it is also necessary to consider the national characteristics of each country. Directions for further improvement of the financial monitoring system in Ukraine have been identified, i.e., enhance international cooperation, prevent the use of legal entities and organizations for criminal purposes, improve investigation and prosecution procedures for money laundering, especially considering international assistance received in the fight against Russian aggression, review investigation procedures and criminal prosecution in financing terrorism, and apply financial sanctions for the financing of terrorism.

Keywords: FATF, financial monitoring, system for countering money laundering and financing terrorism, terrorism, Ukraine

JEL: D81, E44, F30, G18

Introduction

In the context of intensified international terrorism, one of the threats to state security is the legalization of illegally obtained income and the financing of terrorist activities. An effective financial and legal tool to counteract these risks is financial monitoring. In spite of being a relatively new phenomenon for Ukraine, it has undergone important stages of its formation. In order to assess the changes taking place with financial monitoring today, it is necessary to determine the essence of this concept and its main components.

Currently, many countries are creating their own financial monitoring system in order to counteract the legalization of proceeds from crime and combat the financing of terrorism. In turn, this is due to the challenges of the global fight against money laundering and the financing of terrorism. The first real steps taken by Ukraine in the fight against money laundering and the financing of terrorism began, in fact, in 2002. It was during this period that Ukraine was included in the list of countries with a high level of criminalization of the economy that pose a potential threat to the world community (Bisaga 2016). As Tikhonenko and Radchenko (2019) rightly pointed out, "Ukraine's blacklisting by the FATF (Financial Action Task Force) has become a catalyst for the development of the regulatory framework in the field of combating money laundering. As a result, this process became productive and led to the exclusion of Ukraine from this list in 2010."

Literature review

The study of financial monitoring to combat money laundering and terrorist financing is an interdisciplinary task that requires reference to the work of academics who have studied various aspects of this problem. Financial monitoring is the object of research in the fields of financial law, finance, public administration, and national security. That is why academics consider financial monitoring as a form of (financial) control (Klymenko 2005), a set of actions and measures (Berizko 2006; Gavrilishin 2008), and a mechanism for the implementation of state management decisions (Baranov 2018).

In general, academics consider financial monitoring to be part of the system aimed at preventing and combating the legalization (laundering) of incomes and the financing of terrorism, often equating it with these processes. We support the position of researchers (e.g., Kurishko 2012; Vozniakovska 2012), who state that financial monitoring is only part of this system, which also includes the law enforcement unit.

Despite the significant progress made by academics, several problems that require thorough research have received only partial or no attention at all. In particular, it is necessary to study foreign experience in the way national financial monitoring systems function to determine development directions and identify opportunities for implementation in domestic practice.

Data and methodology

The methodological basis for the study of financial monitoring includes general scientific and special methods. To improve the categorical-conceptual apparatus, the methods of induction, analysis and synthesis were used. In the course of the study, the following methods are applied:

- a static method (the statistical data of state bodies were analyzed in terms of their activities to combat the financing of terrorism),
- a comparative method (to analyze existing foreign practices in the way national financial monitoring systems function),
- a graphical method (to build profiles of the effectiveness of anti-money laundering systems and the handling of proceeds of crime and financing of terrorism).

The research methodology is based on the analysis of official static data, information materials from the official websites of international organizations and competent national authorities.

Results and discussion

When considering the issues of financial monitoring, academics typically focus on aspects deemed crucial in the context of their study. In particular, in the realm of financial law, this involves a focus on a collection of legal documents, while finance scholars emphasize operations involving funds, among other considerations. Despite this diversity, most academics adhere to the definition established at the legislative level. This definition encompasses a series of measures taken by entities engaged in financial monitoring to prevent and counteract activities, encompassing both state financial monitoring and primary financial monitoring. Moreover, the role of financial monitoring in the fight against terrorism is also determined: "[…] it makes it possible to punish the perpetrators of crimes and prevent them from using the money received as a result of committing crimes. Financial monitoring is a fairly promising branch of the fight against criminal activity on the territory of Ukraine and beyond" (Semeklit and Ivanov 2019).

In our opinion, when disclosing the essence of financial monitoring, it is advisable not to dwell solely on the subjects; other components should also be covered. Stable and effective functioning of the national system of combating the financing of terrorism requires a comprehensive application of methodological, organizational, legal and institutional measures. Based on the fact that financial monitoring is a set of such measures, we consider it expedient to single out appropriate security in its structure.

We believe that the main component is institutional support, manifested through the entities involved in financial monitoring, their hierarchy, and coordination. These factors affect other components of the financial monitoring system and determine its effectiveness as a whole. Thus, certain bodies, in particular, the State Financial Monitoring Service (SFMS), are engaged in methodological support. This support involves the development of approaches, principles and methods for financial monitoring. In particular, the SFMS has compiled essential international documents, which are the basis for building and evaluating a system for preventing and combating the legalization of income (money laundering) and financing terrorism. The adopted methodological approaches established requirements for organizational security, covering professional personnel and instructive materials for them, as well as legal and regulatory security, which includes a range of documents both at the legislative and by-law levels.

Given the above, when assessing the effectiveness of financial monitoring, considerable attention is paid to institutional support, which is reflected in the performance indicators of the SFMS. In 2018, the investigation of the SFMS recognized it as among the best financial intelligence units in the world. According to the voting results of the financial intelligence units of 150 countries of the world, the SFMS received the "Best Case of the Egmont Group" award. In addition, Ukraine has successfully passed

the assessment of the system for combating money laundering and the financing of terrorism by the Committee of the Council of Europe MONEYVAL (FinPost 2019).

Based on the 2021 results, the SFMS sent 109 materials to law enforcement agencies (of which 83 were generalized materials and 26 were additional generalized materials) regarding financial transactions of people that may be related to financing terrorism, separatism, and/or conducted with the participation of people publicly calling for a violent change or overthrow of the constitutional order or a change in the borders of Ukraine (State Financial Monitoring Service of Ukraine 2021). In 2020, this figure was 75 materials, in 2019 – 106, in 2018 – 100, and in 2017 – 69 (Figure 1).

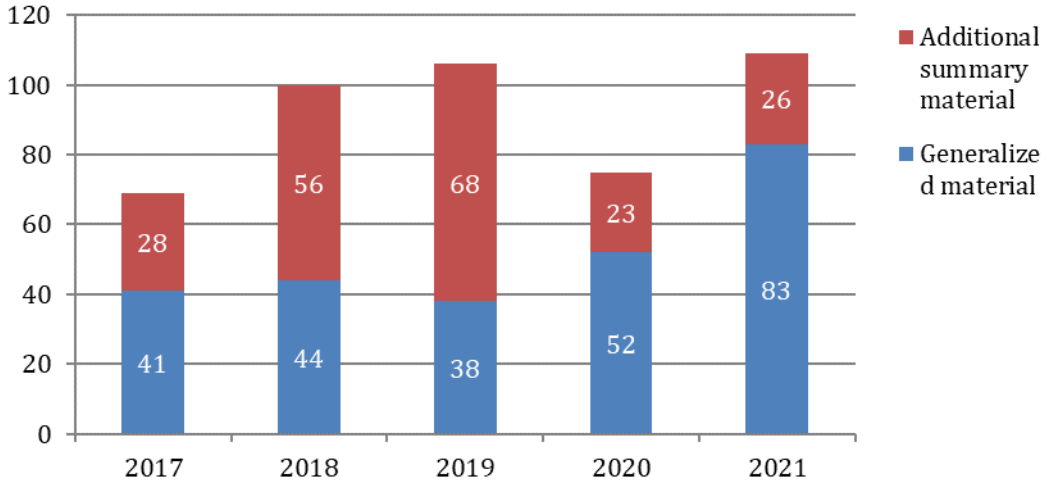


Figure 1. The number of materials on financial transactions of people that may be related to the financing of terrorism sent by the SFMS to law enforcement agencies between 2017 and 2021

Source: based on the State Financial Monitoring Service of Ukraine (2017–2021).

Considering Russia's open military attack on Ukraine in 2022, as well as the difficult military-political situation in the East of Ukraine for several years before that, it is natural that there has been an increase in the number of materials that the SFMS passes to law enforcement agencies. It indicates proper institutional support and financial monitoring, which makes it possible to identify a large number of terrorist financing schemes. We believe that the decrease in the number of materials in 2020 could be due to more cautious steps taken by people associated with the financing of terrorism due to changes in the rules of financial monitoring in that year. However, the assessment of Ukraine's financial monitoring system should be compared to foreign practices to be able to identify weaknesses and strengths and determine the directions for its development.

Among the goals of creating an international system to combat the legalization of proceeds from crime and the financing of terrorism, which has developed as a result

of a number of initiatives of international organizations, structures and individual states, one can single out suppression of crimes in this area. They include undermining the financial foundations of transnational organized crime and international terrorism, protecting financial institutions and the entire financial and economic system from the penetration of dirty money into them, and ensuring their stability and security.

Organizationally, the international system to combat the legalization of proceeds from crime and the financing of terrorism is comprised of international and regional organizations, as well as structures that are not formally international organizations, although they play a significant and sometimes leading role in this international system. One such multilateral organization is the FATF (Financial Action Task Force). While performing its main functions, FATF presents results that relate to combating the financing of terrorism. It also provides recommendations intended to guide countries in the fight against money laundering and terrorist financing. It produces three major typology reports detailing trends and challenges in terrorist financing. Additionally, the organization conducts mutual evaluations of the regimes of member countries to combat money laundering and terrorist financing, maintaining a "black list" and "grey list" of members recognized as having deficiencies according to FATF standards.

However, despite the presence of a clearly defined approach to countering the legalization of proceeds from crime and the financing of terrorism at the international level, national systems can differ significantly under the influence of many factors. Therefore, FATF must take into account the culture of the individual country, since cultural reasons are fundamental factors in the rules of a country and the nature of its monetary system. It is clear that the founders of FATF left their cultural imprint on the system of requirements and recommendations of this organization, with developing countries not participating in the development of these recommendations. However, these countries have great cultures and religious values, which can have a significant impact on how a country implements its rules and financial system and, accordingly, its financial monitoring system.

Different systems have significant differences, primarily related to historical and cultural features. Countries treat the crimes of money laundering and financing terrorism with varying degrees of importance, for both legal and political reasons. This inevitably affects the amount of resources spent on the fight and the level of effectiveness and involvement of the country in the system of combating money laundering and financing terrorism. National financial monitoring systems are constantly changing and improving. The reason for this is the new challenges presented by money laundering.

Today, the system of international cooperation on this issue is developing quite rapidly, and the range of subjects and evaluation criteria is expanding. That is why it is impossible to overestimate the study of foreign experience in how the financial monitoring system functions. Its significance is manifested in the possibility

of identifying reserves to improve the effectiveness of national systems, as well as the international system for combating the legalization of proceeds from crime or financing terrorism. This, in turn, fosters the development of effective international cooperation in this area.

The assessment of national systems for combating the financing of terrorism is incomplete without revealing the effectiveness of their analysis, which is advisable, given their compliance with the requirements and recommendations of FATF.

In contrast to assessing technical conformity, evaluating effectiveness is subjective since it is not a statistical task and depends on the decision and the qualifications and interests of experts. While data and statistics are important sources of information for experts, the determination of effectiveness is based on qualitative information. This assessment considers the specific situation of the jurisdiction, making it possible to conclude whether this national system achieves the desired result (Melkumyan 2017).

In turn, the FATF recognizes a direct relationship between effectiveness and the level of technical compliance with the FATF Recommendations: the lower the technical compliance rating, the less effective the system is for combating money laundering and terrorist financing. However, a high technical compliance rating does not guarantee that this system is effective. In exceptional cases, with a low level of technical compliance, there is a certain level of effectiveness due to the unique situation in the country. This includes low risks or other structural or material factors, peculiarities of the legislation and institutions of the country, and the use of compensatory measures to combat money laundering and the financing of terrorism that are not required by the FATF Recommendations (FATF 2013–2021).

Based on the published summary ratings of countries that passed the next round of assessments of the FATF methodology in 2013, we will determine the countries that received the highest rating in 11 results (Table 1).

Table 1. Effectiveness rating of national anti-money laundering and counter-terrorist financing systems based on highly rated results

No.	Result	Highly rated countries and year of rating round
1	Risk, Policy and Interaction (IO1)	Bermuda (2020), UK (2022)
2	International Cooperation (IO2)	New Zealand (2022), Finland (2021), France (2022), Sweden (2020)
3	Supervision (IO3)	–
4	Preventive measures (IO4)	–
5	Legal entities and arrangements (IO5)	–

No.	Result	Highly rated countries and year of rating round
6	Financial Intelligence (IO6)	Israel (2022), Spain (2019), Russian Federation (2019)
7	Investigation and Prosecution of Money Laundering (IO7)	–
8	Confiscation (IO8)	Honduras (2020), Israel (2022), New Zealand (2022), USA (2020), France (2022)
9	Investigate and prosecute terrorist financing (IO9)	UK (2022), Israel (2022), Russian Federation (2019), USA (2020), France (2022)
10	Preventive measures and financial sanctions for terrorist financing (IO10)	UK (2022), US (2020)
11	Financial sanctions for financing the proliferation of weapons of mass destruction (IO11)	UK (2022), US (2020)

Source: compiled from Consolidated table of assessment ratings (2022).

According to this ranking, the most effective anti-money laundering and counter-terrorist financing systems are in place in the United States and the United Kingdom (which had the highest score for four outcomes), as well as Israel and France (which had the highest score for three outcomes).

The USA has created an effective financial monitoring system, with a large number of state bodies and institutions involved. The US Department of the Treasury created the 'world's first financial intelligence agency to identify actors for sanctions and support preventive measures to combat money laundering and terrorist financing. The Intelligence and Analysis Department of the Ministry of Finance is tasked with identifying and undermining the financial system of terrorist groups, as well as identifying vulnerabilities in its financial system that can be exploited by terrorist actors. Financial intelligence in the United States fights against financial crimes, and its main function is to provide information assistance to law enforcement agencies to combat money laundering and the financing of terrorism.

In general, in the United States, supervision in the field of combating money laundering and the financing of terrorism across the banking sector and the securities market is recognized as the most reliable, and the use of special sanctions against entities involved in money laundering and the financing of terrorism is quite effective. Of the 40 FATF recommendations, 31 recommendations in the US were rated compliant or significantly compliant, five were partially compliant, and four were non-compliant (FATF 2020).

However, the system does have shortcomings. Notably, the US does not recognize all entities designated by the UN as undesirable. There is limited coverage of investment advisors, the self-employed, and real estate agents with special requirements for combating

money laundering and terrorist financing. This reflects the vulnerability of this sector to the risks of money laundering and terrorist financing. Furthermore, there is a lack of a unified approach to anti-money laundering efforts at the state level (FATF 2021).

The UK, as the world's largest financial services provider, faces significant risk that funds are closely linked to crime and terrorism. This is reflected in national policies, strategies and systems for combating money laundering and the financing of terrorism. Law enforcement agencies have broad powers to obtain information about the benefits of the acquirers, which effectively affects the results of relevant investigations. The strengths of the UK's national financial monitoring system include its wide range of preventive activities, the supervisory and regulatory authorities, as well as a system of measures to prevent criminals from professional accreditation and gaining control over a financial institution. At the same time, the intensity of the struggle in different sectors is not the same, which can be risky for the national system (FATF 2021). The UK is highly effective in investigating and prosecuting crimes related to financing terrorism. To this end, it has taken on the primary burden of identifying terrorists at the UN and EU levels. The UK contributes to achieving a high level of effectiveness in the introduction of targeted financial sanctions.

The UK has four high scores for compliance with the FATF recommendations, which are found to be highly effective, four are very effective, and three are moderately effective. Out of 40 FATF recommendations, 24 were in full compliance, 15 were in significant compliance, and one was in partial compliance (FATF 2022c).

The national financial monitoring system in Israel is also recognized as effective in many areas. Its anti-money laundering and counter-terrorist financing system includes all relevant competent authorities. However, there are also significant drawbacks. For example, not all financial agents are included in the monitoring of money laundering and terrorist financing (real estate agents, dealers in precious metals, trust and corporate service providers), and those already included are not always properly supervised. In terms of FATF compliance, full compliance was recorded for 17 recommendations, 17 recommendations were in significant compliance, five were in partial compliance, and for recommendation No. 17, compliance is not applied due to national characteristics (FATF 2022b)

France's anti-money laundering and terrorist financing system is complex yet reliable. It is effective in many aspects, in particular, in the involvement of law enforcement agencies. France faces a number of money laundering threats, including tax fraud and drug trafficking, and it has also been characterized by a high level of terrorist threats and terrorist financing since the 2015 attacks. Realizing these risks, the country has taken a number of measures to mitigate them, in particular, the effective organization of cooperation between the prosecutor's office and investigative and intelligence agencies. France has three high scores in compliance with the FATF recommendations, which

are recognized as high performance. Of the 40 FATF recommendations, 19 were in full compliance, 18 were in significant compliance, and three were in partial compliance (FATF 2022a).

The compliance levels of national systems for combating money laundering and financing terrorism with FATF's international standards are as follows: the UK – 97.5% (39 out of 40), France – 92.5% (37 out of 40), Israel – 87.5% (35 out of 40), and the United States – 77.5% (31 out of 40). Thus, the national system of financial monitoring of Great Britain is recognized as the most effective.

It is also necessary to assess the worst system of financial monitoring; it is found in China. Legislation to combat money laundering and the financing of terrorism, unlike the practice of developed countries, was created from the very beginning to take into account the recommendations and standards of the FATF. China has many special economic zones, which leads to a number of financial threats to the country. Despite strict regulations regarding money laundering and the financing of terrorism, China is recognized by the FATF as "a state that takes measures that are exclusively beneficial for itself, and at the same time looks 'through its fingers' at the flows of money that are laundered on their territory that are moving from other countries" (FATF 2021).

When analyzing the technical compliance of China's anti-money laundering and counter-terrorist financing systems with the 40 FATF recommendations, the percentage of compliance with international standards is 62.5% (according to the compliance criteria, it "complies" and "substantially complies"). By comparison, the figure for Pakistan is 87.5%. Thus, of the reviewed financial monitoring systems, China is the least in line with international standards regarding combating money laundering and financing terrorism since its compliance with the FATF recommendations was not established in the rating (FATF 2021).

The evaluation of the effectiveness of Ukraine's financial monitoring system requires analysis not only in comparison with the best and worst foreign practices but also in relation to countries in a similar military-political situation. In particular, the choice of such countries is due to the best results based on the results of mutual assessments on many criteria (Great Britain, the United States), low ratings (China), similar provisions regarding the introduction of threats to country security (Georgia, Moldova, Pakistan), and prospects for the convergence of military and economic systems, and in some sectors, a possible merger (Poland).

As a justification for the need to single out the penultimate group of countries, the following facts should be pointed out:

- in 2008, there was also an armed conflict with the Russian Federation in Georgia;
- in Moldova, there is also a quasi-state entity similar to the Donetsk People's Republic and the Luhansk People's Republic – the self-proclaimed Pridnestrovian Moldavian Republic;
- Pakistan is party to an armed conflict with India over Kashmir.

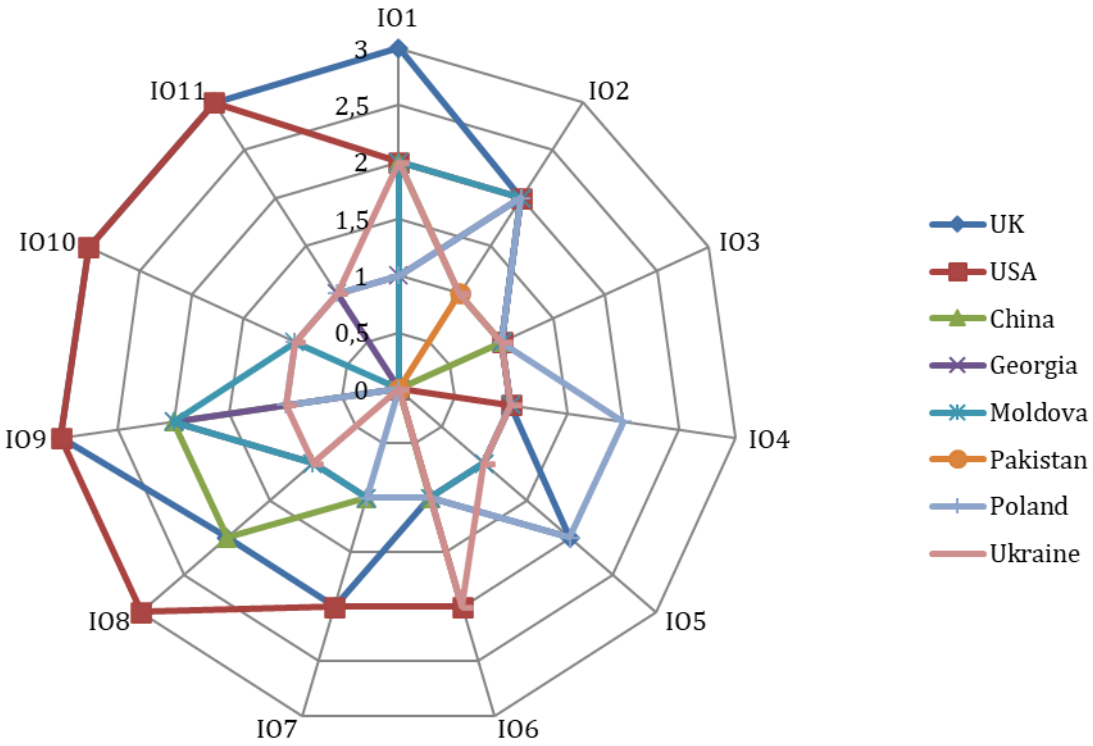
Table 2 has been compiled based on the relevant FATF statistics. It reflects the advantages and strengths of the national systems of Great Britain, the USA, China, Georgia, Moldova, Pakistan, Poland and Ukraine. For the graphical analysis of the data, the qualitative criteria of the compliance ratings were given quantitative values, namely: highly effective (HE) corresponds to 3 (no shortcomings); significantly effective (SE) – 2 (there is a need for minor improvements); moderately effective (ME) – 1 (there is a need for significant improvements); low effectiveness (LE) – 0 (requires fundamental improvements).

The effectiveness profiles of anti-money laundering and anti-terrorist financing systems in the UK, USA, China, Georgia, Moldova, Pakistan, Poland and Ukraine for 11 immediate results are presented in Figure 2.

Table 2. Comparative analysis of the assessments of the effectiveness of national systems for combating money laundering and financing terrorism in the UK, USA, China, Georgia, Moldova, Pakistan, Poland, and Ukraine based on the FATF methodology

№ з/п	Result	Country															
		Great Britain (2022)		USA (2020)		China (2020)		Georgia (2020)		Moldova (2019)		Pakistan (2021)		Poland (2021)		Ukraine (2020)	
		Level	Score	Level	Score	Level	Score	Level	Score	Level	Score	Level	Score	Level	Score	Level	Score
1	IO1	HE	3	SE	2	SE	2	ME	1	SE	2	LE	0	ME	1	SE	2
2	IO2	SE	2	SE	2	ME	1	SE	2	SE	2	ME	1	SE	2	ME	1
3	IO3	ME	1	ME	1	ME	1	ME	1	ME	1	LE	0	ME	1	ME	1
4	IO4	ME	1	ME	1	LE	0	ME	1	ME	1	LE	0	SE	2	ME	1
5	IO5	SE	2	LE	0	LE	0	ME	1	ME	1	LE	0	SE	2	ME	1
6	IO6	ME	1	SE	2	ME	1	ME	1	ME	1	LE	0	ME	1	SE	2
7	IO7	SE	2	SE	2	ME	1	ME	1	ME	1	LE	0	ME	1	LE	0
8	IO8	SE	2	HE	3	SE	2	ME	1	ME	1	LE	0	LE	0	ME	1
9	IO9	HE	3	HE	3	SE	2	SE	2	SE	2	LE	0	ME	1	ME	1
10	IO10	HE	3	HE	3	LE	0	LE	0	ME	1	LE	0	ME	1	ME	1
11	IO11	HE	3	HE	3	LE	0	ME	1	LE	0	LE	0	ME	1	ME	1
Overall score		23		22		10		12		13		1		13		12	
Average score		SE	2.1	SE	2	LE- ME	0.9	ME	1.1	ME	1.2	LE	0	ME	1.2	ME	1.1

Source: based on Consolidated table of assessment ratings (2022).



Legend:

IO1 – Risk, policy and interaction;

IO2 – International cooperation;

IO3 – Surveillance;

IO4 – Preventive measures;

IO5 – Legal entities and arrangements;

IO6 – Financial intelligence;

IO7 – Investigate and prosecute money laundering;

IO8 – Confiscation;

IO9 – Investigate and prosecute terrorist financing;

IO10 – Preventive measures and financial sanctions for terrorist financing;

IO11 – Financial Sanctions for Financing Proliferation of Weapons of Mass Destruction

Figure 2. Effectiveness profile of anti-money laundering and counter-terrorist financing systems in a number of countries according to the FATF methodology

Source: based on summarized data in Table 2.

The analysis of the effectiveness profile of the systems for combating money laundering and terrorist financing in Figure 2 allows us to draw the following conclusions:

- high performance levels were achieved by the UK and the USA in four indicators – IO1, IO9, IO10, IO11 and IO8, IO9, IO10, IO11;
- only in terms of IO2 – international cooperation – did none of the countries need fundamental improvements. Nevertheless, this indicator for Ukraine is lower than for other countries in a similar military-political situation;

- only in terms of IO6 – financial intelligence – does Ukraine have an indicator with a significant level, the same as the United States and higher than that of all other countries studied;
- a moderate level of effectiveness is characteristic of the IO3 indicator for the countries studied, and for Pakistan, it is at a low level.

The evaluation of the effectiveness of national systems for combating money laundering and financing terrorism shows that Ukraine has practically the same indicator values as other countries with similar military situations. However, investigating and prosecuting the laundering of the proceeds from crime has higher indicator values. The values establish directions for further actions for the Ukrainian state.

All national financial monitoring systems must meet the requirements of international standards, taking into account the national characteristics of each country. While variations in detailed legal solutions are acceptable based on specific internal conditions, the implementation of fundamental principles should maintain a high standard. Given the trends in the development of information and computer technologies, in particular, the digitalization of the world economy, it is necessary to pay attention to international cooperation in terms of virtual assets and how they are connected to money laundering and financing terrorism.

Conclusions

A stable and effective national system to combat the financing of terrorism requires the comprehensive use of methodological, organizational, legal and institutional measures. Given that financial monitoring encompasses a range of such measures, it is appropriately integrated into its structure. To ensure an effective international system for combating money laundering and the financing of terrorism, all national financial monitoring systems must comply with the requirements of the FATF international standards, although the national characteristics of each country must be considered.

Based on the results of the research, it can be noted that for most foreign anti-money laundering and counter-terrorism financing systems, risks associated with the use of cash remain relevant. Additionally, there is a lack of sufficient measures to combat the financing of terrorism (except for the USA and the UK), which reduces the effectiveness and efficiency of the financial monitoring system. The study of practices in organizing national anti-money laundering and counter-terrorism financing systems, both in leading countries in this field and in those facing similar issues to Ukraine, has allowed us to identify directions for further improvement of the financial monitoring system in Ukraine. Specifically, the following measures should be taken:

- International cooperation should be enhanced. This is crucial for obtaining necessary information and evidence and coordinating joint actions in the fight against criminals and terrorists. This aspect has higher significance in the UK, the USA, Poland, Georgia, and Moldova.
- Legal entities and organizations should not be exploited for criminal purposes. Ensuring the accessibility of information regarding their beneficial ownership is essential. This aspect is more developed in the UK, the USA, and Poland than in Ukraine.
- Improving investigation and prosecution procedures for money laundering is crucial, particularly in the context of international assistance received in the fight against Russian aggression. Ukraine, in particular, should learn from the experiences of not only the UK and the USA but also Poland, Moldova, Georgia, and even China.
- Investigation and criminal prosecution procedures regarding financing terrorism should be reviewed, as should the use of financial sanctions for financing terrorism. Given the high threats in this area for Ukraine, it is necessary to follow the best practices of the UK and the USA.

Considering international experience, it is essential to improve the Ukrainian anti-money laundering and counter-terrorism financing system by increasing the detail level in the rules. Additionally, efforts should be made to enhance economic transparency and prevent the misuse, misappropriation, and embezzlement of budgetary funds.

The assessment of financial monitoring systems showed that countries are customizing detailed legal solutions to address their internal, specific conditions. However, the implementation of basic principles remains at a high level. Given the trends in the development of information and computer technologies, in particular, the digitalization of the world economy, Ukraine must pay attention to international cooperation in the field of virtual assets and their connection with money laundering and terrorist financing.

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Ocena systemów monitoringu finansowego: doświadczenia ukraińskie i zagraniczne

W artykule scharakteryzowano monitoring finansowy jako element systemu zapobiegania i przeciwdziałania legalizacji dochodów oraz finansowaniu terroryzmu. Celem prowadzonych badań było zbadanie doświadczeń dotyczących funkcjonowania krajowych systemów monitoringu finansowego (w Wielkiej Brytanii, USA, Chinach, Gruzji, Mołdawii, Pakistanie, Polsce i Ukrainie) w celu określenia kierunków rozwoju i zidentyfikowania możliwości ich wdrożenia w praktyce krajowej. Metody badawcze obejmowały indukcję, analizę i syntezę, metody statyczne, porównawcze i graficzne. Metodologia badań opierała się na analizie oficjalnych danych statycznych i materiałów informacyjnych z oficjalnych stron internetowych organizacji międzynarodowych i właściwych organów krajowych. W artykule dokonano analizy danych statystycznych organów państwowych Ukrainy pod kątem ich działalności w zakresie zwalczania finansowania terroryzmu. Skonstruowano również profile służące ocenie skuteczności systemów przeciwdziałania praniu brudnych pieniędzy, a także postępowania z dochodami z przestępczości i finansowania terroryzmu w wielu krajach, zgodnie z metodologią FATF (Financial Action Task Force). Wyniki pokazują, że wszystkie krajowe systemy monitorowania finansowego muszą spełniać wymagania FATF. Konieczne jest jednak również uwzględnienie specyfiki narodowej każdego kraju. Wskazano kierunki dalszego doskonalenia systemu monitoringu finansowego na Ukrainie, tj. wzmocnienie współpracy międzynarodowej, zapobieganie wykorzystywaniu osób prawnych i organizacji do celów przestępczych, poprawa procedur dochodzeniowych i ścigania prania pieniędzy, zwłaszcza biorąc pod uwagę międzynarodową pomoc otrzymywaną w walce z rosyjską agresją, przegląd procedur dochodzeniowych i ścigania karnego w finansowaniu terroryzmu oraz stosowanie sankcji finansowych w finansowaniu terroryzmu.

Słowa kluczowe: FATF, monitoring finansowy, system przeciwdziałania praniu pieniędzy i finansowaniu terroryzmu, terroryzm, Ukraina

Comparative Economic Research. Central and Eastern Europe
Volume 27, Number 2, 2024
https://doi.org/10.18778/1508-2008.27.18

A Comparative Study of Capital Structure Determinants: Agricultural Businesses in Central-Eastern vs. Western EU Countries

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Abstract

This article undertakes a comparative analysis to investigate the distinctive determinants of capital structure in agricultural businesses located in Central and Eastern Europe (CEE) and Western Europe (WE). Given the unique financing characteristics inherent to agricultural enterprises and the substantial economic and historical distinctions between these regions, the exploration of financing strategies within this sector constitutes a crucial research task. The study incorporates financial data from agricultural firms operating in 12 European Union (EU) countries from 2000 to 2020, sourced from the BACH-ESD database. The primary analytical approach involves the application of panel data regressions, separately conducted for the two specified groups of 12 EU countries. The comparative analysis investigates the consistency of factors that affect the capital structure of agricultural firms between CEE and WE countries. The findings reveal that although there is no significant divergence in capital structure across countries, the influence of individual factors exhibits variability across the two macro-regions. The comparative analysis provides valuable insights for policymakers, financial institutions, and agricultural businesses in both groups of countries. Understanding the nuances of capital structure determinants specific to each region can aid in the development of more targeted and effective financing policies. Moreover, agricultural businesses should consider region-specific factors when making financial decisions. This research contributes to the existing literature by shedding light on the differences and similarities in the capital structure determinants of agricultural businesses in CEE and WE. It not only deepens our understanding of how financing strategies vary across regions but also highlights the importance of recognising the unique financial landscape of agricultural

Received: 4.05.2023. Verified: 17.10.2023. Accepted: 2.02.2024

enterprises. By doing so, this study adds substantial value to the field of agricultural finance and provides grounds for more informed decision-making in the sector.

Keywords: Pecking-order theory, trade-off theory, agriculture holdings, leverage, farm finance

JEL: G32, Q140

Introduction

The capital-intensive nature of agricultural production generates a high demand for financial resources. This problem mainly concerns investments. Therefore, the need to modernise and renew existing resources on farms forces these operators to seek sources of capital that can meet their needs. Unfortunately, limited access to finance is a significant obstacle to achieving the sustainable development of agricultural firms across the EU (Tropea and De Carvalho 2016, pp. 1–12). Unlike manufacturing or service businesses, farms do not have direct access to most of the financial instruments the capital market offers. They use a very narrow range of financing sources, including internal funds, short- and long-term loans and various subsidies. However, for agricultural firms, as for all other business entities, the problem of shaping their capital structure is one of the most critical aspects of financial decisions. Agriculture has specific characteristics that distinguish it from other sectors, and they also affect the financial decisions of agricultural firms.

The analysis of capital structure in different countries poses additional problems due to the various economic conditions, as exemplified by the countries of Central and Eastern Europe (CEE). During the socio-economic transition, these countries had a similar level of socio-economic development. However, despite the similarities, the CEE countries did not develop at the same pace. Differences included the conditions and level of development of the agricultural sector, which was largely due to the structure of agriculture and the availability of financial resources for modernisation and restructuring.

This article aims to assess the impact of selected factors on the capital structure of agricultural firms in CEE countries compared to Western European (WE) countries, and to determine whether these firms make financial decisions according to trade-off theory or pecking-order theory. There are only a few studies on this topic in the literature, so this article also aims to fill the gap. To achieve the research objective, two main hypotheses are verified: The financing patterns of agricultural firms are significantly different between CEE and WE countries (H1), and the influence of capital structure determinants also varies between these two groups (H2).

The article consists of an introduction, five parts and a conclusion. The first part indicates the characteristic features of agriculture in the context of capital structure formation.

The second part deals with the formation of the capital structure of farms according to the assumptions of the trade-off theory and the pecking-order theory. It also explains the links between the factors analysed and the level of indebtedness on the grounds of the main theoretical trends, which forms the basis for formulating research hypotheses. The next section reviews the available research on the capital structure of companies in the agricultural sector. This is followed by a presentation of the research methodology, detailed hypotheses and research results, and concludes with a summary.

Distinctive features of the agriculture industry in terms of capital structure

Agricultural firms are characterised by distinctive features that arise from the specific nature of agricultural activity. These characteristics significantly affect the capital structure of these entities. They include the seasonality of agricultural production, the family nature of most farms, the unique life cycle of the farm, unlimited responsibility for liabilities, a specific taxation system, an extensive system of subsidising activities, and the unique nature of land understood as a productive asset (Zhengfei and Lansink 2006, pp. 644–656).

The debt financing of operations is a standard solution in agriculture. The seasonal nature of agrarian production creates a significant lag between incurring expenditure and receiving receipts. Firstly, the financing gap that occurs between these two events establishes the need for external financing. Second, the high level of risk that accompanies agricultural activity and the low profit margins mean that debt is treated as a buffer against the profit volatility associated with seasonality. Furthermore, in most cases, farms are deprived of access to equity capital (Ahrendsen, Collender, and Dixon 1994, pp. 108–119). It is also important to highlight the constraints on access to debt financing that farms with poor financial health may face. It is noted, however, that applying the capital structure theories described in the next section of this paper may either be difficult in practice or produce surprising results in the agricultural sector because of the fundamental differences between farms and other businesses.

In the agricultural sector, the predominant form of business organisation is the family farm, where the workforce consists mainly of family members. Compared to enterprises employing workers on a market basis, such a model can be problematic, as there is no possibility of reducing the number of employees in difficult times. This can further worsen the entity's financial situation. The possible bankruptcy of a family farm means that the lifestyle of the farmer and their family will have to change, which increases the costs of bankruptcy (Zhengfei and Lansink 2006, pp. 644–656).

Family farms have a unique life cycle, significantly influencing capital structure decisions. This cycle consists of four stages: start-up (entry), expansion, consolidation and exit or divestment. According to this approach, debt levels are high when the farmer invests in developing the farm. Then, during the consolidation phase, the proportion of debt in the capital structure decreases as the income generated from the farm peaks and provides internal financing (Kay and Edwards 1994, pp. 218–219). It is worth noting that making the level of leverage dependent on the farm's life cycle can distort the results of capital structure studies.

Unlike companies in other sectors, agricultural businesses mainly operate as sole proprietorships or partnerships. The owners of such entities have unlimited liability for the farm's obligations. Banks that extend credit or loans to such a farm require that security be provided over production assets and housing. For the farmer, this means the risk of losing personal assets, especially their residence. The agency costs associated with the capital structure of agriculture are, therefore, secondary to those of other sectors. In agriculture, the interests of the owners of the capital (farmers) are, to some extent, aligned with those of the creditors. For the same reason, the disciplinary role of debt is more important in agriculture than in other sectors.

How farms are taxed differs from that of enterprises in other sectors. Farmers operating as a sole proprietorship or partnership generally pay tax on their personal income. In the Netherlands, such tax is calculated jointly on the agricultural and non-agricultural income of all family members working on the farm (Zhengfei and Lansink 2006, pp. 644–656). In contrast, Poland has an agricultural tax based on the area of agricultural land. The taxation method changes the tax burden's importance in shaping the capital structure, but does not exclude the use of various types of tax deductions (shields).

EU farms can benefit from government and EU subsidies, which increases their financial capacity. The level of subsidisation of agricultural activities is many times higher than in other sectors. Subsidies help to increase farm cash flow and reduce the need for debt capital. However, as farmers look for opportunities to continue to receive subsidies for their activities, they may choose subsidised solutions. Still, those solutions may not be conducive to high income in the long term.

A final feature that distinguishes agriculture from other sectors is the need for agricultural land. Land as a means of production is seen as a non-destructive asset, which is its unique characteristic. This means, firstly, that land can be used in perpetuity, i.e. there is no depreciation. Secondly, land is ideal collateral for debt, improving farmers' access to credit markets.

EU agricultural firms' financial choices according to the trade-off and pecking-order theories

The main premise of trade-off theory is to optimise the capital structure to maximise the firm's market value. The optimal capital structure, i.e. the combination of debt and equity, is the result of balancing the interest of tax benefits with financial distress costs (bankruptcy costs) together with the agency costs of equity and debt (Myers 1984, pp. 575–592).

Large firms tend to be more diversified. This leads to less volatility in revenues and, therefore, a lower level of risk. Therefore, bankruptcy for such entities is less likely than for smaller firms, and large entities can borrow more (Titman and Wessels 1988, pp. 1–19). The lower profit volatility associated with the diversification of activities characteristic of large firms reduces the indirect costs of bankruptcy so that such a firm can use debt to a greater extent. In addition, entities that have a significant stock of physical assets can use them as collateral for debt. This implies a positive relationship between asset structure and leverage. This hypothesis is particularly relevant for agricultural holdings, which are characterised by a very high share of physical assets, especially land, in the asset structure (Zhengfei and Lansink 2006, pp. 644–656). Like the asset structure, liquidity is positively related to leverage. Firms with high liquidity ratios are willing to use debt because they show an excellent ability to repay liabilities. The liquidity category is linked to and reflected in the working capital, i.e. the difference between current assets and current liabilities. According to trade-off theory, the link between working capital and leverage is positive as companies can increase their debt to finance their working capital requirements.

Firms with high profitability are more indebted because high revenues reduce the likelihood of bankruptcy. It has been stated that subsidies such as government bailouts or EU grants are a driver of improved profitability and financial stability in the agricultural sector, leading to increased indebtedness (Latruffe et al. 2010, pp. 351–365). Agricultural firms face high risks due to various factors, e.g. the weather or the volatility of agricultural prices and costs. These risks lead to increased uncertainty about the value of future cash flows. This may reduce the availability of debt financing, as lenders may perceive agricultural firms as potentially generating higher bankruptcy costs. The relationship between growth opportunities and debt can be similarly explained. Established firms with low growth potential are considered to have a better reputation. Therefore, they can borrow on better terms than growth firms. This is because the realisation of growth opportunities is associated with higher risks and expected costs of financial difficulties, resulting in reduced debt.

According to the trade-off theory, the tax shield effect is one of the reasons that leads to an increase in debt. However, this behaviour is only attractive for companies that

generate income that allows tax benefits to be obtained but that do not have other costs which act similarly to the tax shield. Such costs include, in particular, depreciation, which, as a proportion of total assets, determines the level of the investment tax shield. Unlike the tax shield, it leads to a reduction in debt (DeAngelo and Masulis 1980, pp. 3–29).

Pecking-order theory takes the opposite approach to capital structure formation (Myers and Majluf 1984, pp. 187–222) and explains companies' preferences for particular sources of financing. The order is as follows: Internal sources, i.e. retained earnings, together with surplus cash and short-term financial assets, are used first. Once they are exhausted, companies turn to external sources. Thus, they first turn to loans and bank borrowings, followed by a decision to issue debt securities and only finally to issue shares.

According to the pecking-order theory, profitable companies borrow less. They prefer internal financing because they can accumulate profit and therefore show less need for debt financing (Fama and French 2002, pp. 1–33). Entities with high growth opportunities, which require additional financing for investments after internal funds have been exhausted, first turn to debt financing for risky investments, and only once they have done this will they turn to external equity. Therefore, growth opportunities positively relate to leverage (Myers 1984, pp. 575–592). The high volatility of agricultural returns is associated with an increased likelihood of debt repayment difficulties. Therefore, risk negatively affects leverage (Barry, Bierlen, and Sotomayor 2000, pp. 920–933). According to pecking-order theory, asset structure harms capital structure as firms with a high proportion of tangible assets in their asset structure are less susceptible to problems arising from information asymmetries. Therefore, their propensity to take on debt is lower. Moreover, companies with high liquidity first use accumulated cash and cash equivalents. Therefore, they borrow less (Martucheli 2020, pp. 26–42).

The relationship between working capital and capital structure is the same. To optimise working capital management, firms seek to maintain high liquidity and independence from debt capital. Pecking-order theory predicts both negative and positive effects of firm size on debt levels. However, in the case of agricultural companies, a positive relationship should be considered first and foremost. The lower level of risk that is characteristic of large entities reduces information asymmetry problems. It lowers the cost of debt relative to other sources of financing. For this reason, large companies are more indebted than smaller ones.

The impact of the tax burden on the capital structure is not considered in pecking-order theory (Frank and Goyal 2003). However, the relationship between the non-interest tax shield and debt is negative. Firms that raise funds through depreciation show a lower need for debt capital because they have higher internal financing capacity (Öhman and Yazdanfar 2017, pp. 106–124).

In addition to the company-specific factors, the impact of the country could also be significant regarding financial policies adopted by European agricultural firms. Section 4 highlights the distinct features of agricultural firms in CEE and WE countries, suggesting that differences are likely in the capital structure behaviour across countries.

Empirical studies on the capital structure of agricultural firms

Most studies on capital structure formation focus on large manufacturing, service or financial enterprises. Only a limited number can be found on the agricultural sector. Most studies focus on the markets of highly developed countries, especially the USA, e.g. Barry, Bierlen, and Sotomayor (2000, pp. 920–933) and Zhao, Barry, and Katchova (2008, pp. 805–820). Both studies obtained mixed results, which, however, although they confirmed that the analysed farms make financial decisions primarily according to the principles of pecking-order theory. Steele, Mugera, and Kingwell (2021, pp. 391–412) examined the capital structure factors of Australian farms. The results indicate that, as in the US, financial decisions are made according to the principles of the pecking-order theory of financial sources.

Some of the available research on capital structure concerns agricultural firms of highly developed European countries. For example, Zhengfei and Lansink (2006, pp. 644–656) analysed the impact of capital structure on the profitability and productivity of Dutch agricultural firms. Debt did not affect the profitability of equity, although it did lead to increased productivity. Slightly different results were obtained by Wu, Guan, and Myers (2014, pp. 115–132). They found that the same factors affect the capital structure of agricultural firms in the Netherlands with varying strength depending on the level of indebtedness. Macroeconomic determinants had a more substantial effect on entities with higher leverage, implying that firms should choose their financial strategy depending on their debt level.

Sikveland and Zhang (2020, pp. 1–7) investigated the influence of internal factors on the debt level of Norwegian salmon farms. They found that in unlisted entities, profitability negatively affected the level of short-term debt and total debt. In contrast, public companies relied less on debt than unlisted companies. Furthermore, asset structure positively affected the amount of long-term debt in both listed and unlisted companies. Schoor and Lips (2019, pp. 323–337) conducted a comparative analysis of the optimal capital structure of dairy farms in different regions of Switzerland. They showed that owners of farms located in the mountains exhibited a higher risk propensity than those whose farms were located in the valleys. This was reflected

in a higher proportion of debt in the capital structure of those from mountainous regions than those from lower-lying areas.

Few studies on capital structure factors and financing decisions can be found in the literature for farms in CEE countries. Fertő et al. (2017, pp. 1–7) conducted a comparative analysis of investment decisions of agricultural firms from CEE and WE countries in 2003–2008. Despite the differences in the agricultural structure shown in the analysis and the limited availability of debt capital due to the underdeveloped financial market in the CEE countries, it was found that the investment patterns of the compared farms were similar. Investment expenditure was positively related to sales growth, indicating a preference for internal financing. In addition, subsidies and grants were shown to positively affect investment levels, which mitigated the effects of low credit and loan availability. In contrast, in the long term, they showed the crucial importance of the farm's ability to compete in the market and to receive high revenues from this, which can be used to finance further investments.

Difficulties related to the availability of debt capital were identified as an important factor negatively influencing farm financial decisions by Simonovska, Gjosevski, and Campos (2014, pp. 273–280). They analysed the impact of internal conditions on the capital structure of 26 Macedonian agricultural firms between 2006 and 2010. Despite the underdeveloped financial market, these entities relied heavily on debt financing. Liquidity was an important factor that shaped the capital structure of the analysed farms. Entities with high liquidity made financial decisions following the principles of pecking-order theory. In contrast, farms with less liquidity followed the trade-off theory.

Fenyves et al. (2020, pp. 160–167) investigated capital structure factors in a large sample of agricultural firms from the Visegrad countries (i.e. Czechia, Hungary, Poland and Slovakia) between 2015 and 2017. The results were strongly influenced by the structure of agriculture in each country. Highly profitable farms preferred internal financing in Poland, the Czech Republic, and Hungary. In the Czech Republic, enterprise size influenced the debt increase. In contrast, small farms in the country used debt less due to availability limitations. Asset structure was a significant factor in capital structure only for Hungarian farms, resulting in lower debt levels. Growth opportunities were positively related to leverage in Hungary and Poland, countries with highly fragmented agricultural structures. Polish, Czech and Hungarian farms shaped their capital structure in line with the principles of the pecking-order theory. For Slovakia, on the other hand, the theory was only partially confirmed. Furthermore, the research indicated a strong influence of the country effect on the capital structure of V4 farms.

Similar results on capital structure factors for agricultural holdings in Poland were obtained by Enjolras, Sanfilippo, and Soliwoda (2021, pp. 113–133). Based on data covering the period 2009–2018, they found that the capital structure of Polish farms was positively

related to size and growth opportunities. In contrast, profitability and asset structure negatively impacted the size of their debt. These entities primarily used internal funds, especially retained earnings, which is consistent with the pecking-order theory. Moreover, Polish farms had a low target debt level, which they adjusted dynamically, partially confirming the trade-off theory.

Characteristics of Central and Eastern versus Western EU agricultural firms

The historical development and evolution of EU agricultural enterprises varies from country to country. This variation is not only between CEE and WE but also within these regions. In CEE, the differences in farm size are caused by the conditions that resulted from the previous communist system and the institutional and political reforms introduced during the economic transition. In WE, on the other hand, variations in farm size are mainly related to the long-term impact of market, institutional and political factors. For example, in France and other WE countries that were originally part of the European Economic Community and then the European Community, the contemporary farm structure has evolved mainly under the influence of market mechanisms and the institutional support system that was mainly shaped by the Common Agricultural Policy implemented in 1962 (Fertő et al. 2017, pp. 1–7). It is also worth noting that these countries have a well-developed market for debt financing of agricultural firms. In France, for example, agricultural cooperative banking activities were initiated as early as the 19th century. These institutions were established in response to the difficulty farmers had in obtaining finance through loans and credit from commercial banks (Benjamin and Phimister 2002, pp. 1115–1129).

In Italy, the average farm size is among the lowest in the EU, which is historically and culturally determined (Kochanowicz 1984, pp. 119–125). Contemporary agricultural policy draws heavily on historical tradition, resulting in strong support for small family farms and, consequently, in the predominance of such actors in the agricultural structure (Costato 2007, pp. 11–25).

The structural changes in agriculture in the countries that joined the EU later were somewhat different. In Spain, for example, the transformation within farms in the post-accession period was dynamic. The average size of the farm increased during this period, although it also saw a sharp decrease in the number of small farms. However, EU accession did not increase agricultural income, and in the post-accession period, a significant proportion of farms struggled to achieve adequate levels of profitability and competitiveness (Iraizoz 2008).

The current agricultural structure in Germany is the result of the market, institutional and political factors that have shaped agriculture in the WE countries mentioned earlier. However, the impact of the economic transformation in the former East Germany in the 1990s also played a part. During this period, the importance of family farms and those run in the form of partnerships (Einzelunternehmen) increased. A feature of both entities is unlimited liability for debts. The main reason for creating agricultural partnerships was to overcome the difficulties faced by family farms in accessing debt financing. The last type of agricultural firms to emerge in East Germany due to the transformation are equity companies (Juristische Personen). These entities were mainly created due to the privatisation of state farms, mainly large-scale farms (Mathijs and Swinnen 1997).

Under communism, large state farms strongly dominated agriculture in CEE countries. Their acreage was much larger than the average farm size in WE countries. During the economic transition, land ownership was restored to citizens in most CEE countries, and previously nationalised land and other agricultural assets were re-privatised. The new private owners of the privatised agricultural firms started to operate as family farms. These entities had a much smaller acreage than the earlier state-owned farms, although the acreage of many of the newly established private farms was comparable to those in WE countries. However, not all state farms were converted into family farms. Some continued in the form of capital companies or partnerships. The current structure of agriculture in CEE countries was shaped by the privatisation methods and policies adopted in each country. Ultimately, privatisation led to the creation of small farms in most of these countries. Examples include Romania and Slovenia, where the average farm size is 3.7 and 7 ha, respectively (Eurostat 2023). In Slovakia and the Czech Republic, on the other hand, agriculture is still dominated by large-scale agricultural firms (Ciaian, Pokrivcak, and Drabik 2009, pp. 191–201).

Croatia, one of several countries that emerged from the break-up of Yugoslavia, is characterised by a highly fragmented and polarised farm structure. A small number of large-scale agricultural firms dominate the country's agricultural market. However, there is a lack of medium-sized entities to form the backbone of agriculture and rural development. The remaining farms are tiny and have virtually no production potential. Croatia's agricultural structure is a legacy of the country's socialist past and the subsequent inept privatisation that led to the destruction of large agricultural enterprises and cooperatives. The situation was further complicated by the tragic displacement that took place during the civil war fought between 1991 and 1995 (Mikuš 2014, pp. 95–104).

Economic transformation and EU accession are key factors that shape structural change within the farms of CEE countries. However, the impact of cultural conditions on the agricultural sector cannot be overlooked. In Poland, the deep-rooted tradition of family farming is very strong. Even under communism, the country's agricultural structure

was dominated by private farms. Only a tiny proportion were collectivised and nationalised. In the early 1990s, private agriculture covered 76% of arable land, with only about 23% belonging to the state (Milczarek 2002, pp. 1–137). However, after EU accession, many of the smallest subsistence farms (up to 2 ha) disappeared from Poland because they were not eligible for financial or pension support for farmers.

Data and methods

The source of the data for the analytical part of this study is the BACH database (BACH, 2023), which provides harmonised annual accounts statistics of European non-financial enterprises for twelve EU countries: Austria (AT), Belgium (BE), the Czech Republic (CZ), Germany (DE), Spain (ES), France (FR), Croatia (HR), Italy (IT), Luxembourg (LU), Poland (PL), Portugal (PT) and Slovakia (SK). The database contains aggregated information on company balance sheets, income statements, cash flow statements, and other financial indicators, as well as data on company size and industrial classification. It is published by the European Committee of Central Balance Sheet Data Offices (ECCBSO).

The analysis in this study covers the agricultural industry, i.e. section A according to the NACE classification (Agriculture, forestry and fishing) in 11 countries and three size classes (S – small, M – medium and L – large) between 2000 and 2020. The countries include four CEE countries (Czechia, Croatia, Poland and Slovakia) and seven WE member states (Austria, Belgium, Germany, Spain, France, Italy and Portugal). We have excluded Luxembourg from our analysis. The primary reason for this exclusion is the country's small size, which makes it challenging to compare accurately with other European agricultural producers.

The structure of the analysed data is three-dimensional. The three dimensions correspond to the three size classes of firms, 11 countries and 21 years. Due to the data release delays, 2020 is the most recent year available in 2023. For each object defined by the three dimensions, several dependent and explanatory variables were computed. The construction of these ratios is shown in Tables 1 and 2, respectively.

Table 1. Construction of dependent variables

Symbol	Ratio	Formula
D/A	Total debt ratio	Total debt / Assets
LTD	Long-term debt ratio	Non-current debt / Assets
STD	Short-term debt ratio	Current debt / Assets

Source: authors' own compilation based on BACH (2023).

The selection of explanatory variables aligns with the factors typically examined as the primary determinants of capital structure by other studies in the field.

Table 2. Construction of explanatory variables

Symbol	Ratio	Formula
TAX	Tax burden	Tax on profit / Earnings before tax
TNG	Asset tangibility	Tangible fixed assets / Assets
LIQ	Financial liquidity	Cash and bank / Assets
DPR	Depreciation	Depreciation and amortisation of intangible and tangible fixed assets / Net turnover
ROE	Return on equity	Net profit or loss for the period / Equity
WCR	Working capital ratio	Operating working capital / Net turnover
GRT	Firm growth	(Assets of year *n* + 1 – Assets of year *n*) / Assets of year *n*
RSK	Risk (earnings variability)	(Net profit or loss of the year *n* + 1 – Net profit or loss of the year *n*) / Net profit or loss of the year *n*
SIZE	Size dummies	Dummy variables for size groups: S, M, L
CT	Country dummies	Dummy variables for size countries: AT, BE, CZ, DE, ES, FR, HR, IT, PL, PT, SK

Source: authors' own compilation based on BACH (2023).

The techniques employed in the research match the primary objective, which is to investigate whether the factors that influence the choices regarding capital structure in agricultural firms are consistent in WE and CEE countries.

As differences in debt structures among agricultural companies across countries could vary in importance based on firm size, the initial hypothesis (H1) relating to variation in East/West financing strategies should be separated into three sub-hypotheses concerning distinct size categories. We incorporate an additional digit to H1 for each size category: 1 – all size groups, 2 – small, 3 – medium, and 4 – large firms. Furthermore, since we are examining three debt indicators, the research hypothesis must also be examined independently in terms of diverse debt maturities. As a result, the principal hypotheses are further subdivided. This categorisation is accomplished by utilising the following extensions: a – for total debt, b – for long-term debt, and c – for short-term debt. Consequently, H1 can be clarified, as illustrated in Table 3.

Table 3. The structure of research hypothesis H1 according to debt measures and size classes

Debt ratio	Size class of agricultural firms			
	All sizes	Small	Medium	Large
D/A	H1.1a	H1.2a	H1.3a	H1.4a
LTD	H1.1b	H1.2b	H1.3b	H1.4b
STD	H1.1c	H1.2c	H1.3c	H1.4c

Source: authors' own compilation.

Using the symbols presented in the table, for example, H1.2b would indicate: The long-term debt of small agricultural firms is significantly different between the CEE and WE countries. The remaining hypotheses are constructed in a comparable manner. The second hypothesis (H2), regarding the different influence of capital structure determinants between CEE and WE countries, is broken down into more precise assumptions that pertain to each factor considered as a capital structure determinant. This is done by including a digit in H2 that represents each explanatory variable. The same letter extensions (a, b, c) as for H1 are used for different debt maturities. Thus, H2 can be specified as demonstrated in Table 4.

Table 4. The structure of research hypothesis H2 according to debt measures and explanatory variables

Debt ratio	Independent variables										
	TAX	TNG	LIQ	DPR	ROE	WCR	GRT	RSK	SIZE	CT	YEAR
D/A	H2.1a	H2.2a	H2.3a	H2.4a	H2.5a	H2.6a	H2.7a	H2.8a	H2.9a	H2.10a	H2.11a
LTD	H2.1b	H2.2b	H2.3b	H2.4b	H2.5b	H2.6b	H2.7b	H2.8b	H2.9b	H2.10b	H2.11b
STD	H2.1c	H2.2c	H2.3c	H2.4c	H2.5c	H2.6c	H2.7c	H2.8c	H2.9c	H2.10c	H2.11c

Source: authors' own compilation.

The symbols utilised in Table 4, such as H2.3b, indicate that the impact of liquidity on the long-term debt of agricultural firms differs significantly between the CEE and WE countries. Comparable sub-hypotheses are constructed in a similar manner.

To compare the debt level, the initial phase of the analysis entailed examining fundamental descriptive statistics for agricultural companies across various country and size categories. To test the first set of research hypotheses (H1a–c), an analysis of variance was conducted for the three debt ratios as dependent variables, and the countries were classified into either CEE or WE as the categorical predictor. The second set of research hypotheses (H2a–c) was assessed based on the panel data

regression results that were performed independently for the two groups of EU countries. The model is defined by formula (1):

$$D_{cst} = \beta_0 + \beta_1 TAX_{cst} + \beta_2 TNG_{cst} + \beta_3 CSH_{cst} + \beta_4 DPR_{cst} + \beta_5 ROE_{cst} + \\ + \beta_6 WCR_{cst} + + \beta_7 GRA_{cst} + \beta_8 RSK_{cst} + \gamma_s SIZE + \alpha_c CT + \rho_t YEAR + \xi_{cst} \quad (1)$$

where:

- D_{cst} – one of the three debt measures (D/A, LTD, STD) in c country of firm size s in year t,
- CT – dummy variables representing countries, $c = 1,\ldots 11$,
- $SIZE$ – dummy variables representing size classes, $s = S, M, L$,
- $YEAR$ – dummy variables representing years, $t = 1,\ldots 21$,
- β, γ, α, ρ – coefficients,
- ξ – random factor,
- other variables as specified in Table 3.

We outline the findings in the next section.

Results and discussion

The initial phase of the analysis focused on comparing debt levels, which entailed assessing basic descriptive statistical data for agricultural companies in various country and size categories. The examination of mean debt values in the agricultural sector across 11 EU countries, as depicted in Figure 1, reveals that there are no significant differences within the countries examined. Notably, Croatia had the lowest percentage of total and short-term debt, but this is not a common characteristic for other CEE countries. Conversely, Austrian agricultural firms had the highest mean total and long-term debt levels, while in France, they relied heavily on long-term financing.

Based on the findings presented in Figure 1, it can be concluded that there is minimal discernible variation between individual countries and between the CEE and WE country groups. This conclusion can be supported by the one-way ANOVA results shown in Table 5.

The table reveals that the effect of a firm's location (CEE vs WE) on its debt structure varies depending on the size of the firm and the type of debt. Specifically, for small firms, there is a significant effect of location on total debt and short-term debt, but not on long-term debt. For medium firms, location has a significant effect on both total debt and long-term debt, but not on short-term debt. The absence of a significant impact of location on any type of debt for large firms could be attributed to the likelihood of these

firms operating on a global scale, or at least within European markets, which may reduce their sensitivity to regional factors that affect smaller firms. Finally, for the overall group that includes all size classes, there is no significant effect of location on total debt or short-term debt, but there is a significant effect on long-term debt. Overall, the results suggest that the effect of location on a firm's debt structure is not uniform across different firm sizes and types of debt. These findings only partially confirm the hypothesis regarding significant variations in financing policies among agricultural firms in the two country groups. The details of the H1 hypothesis verification are shown in Table 6.

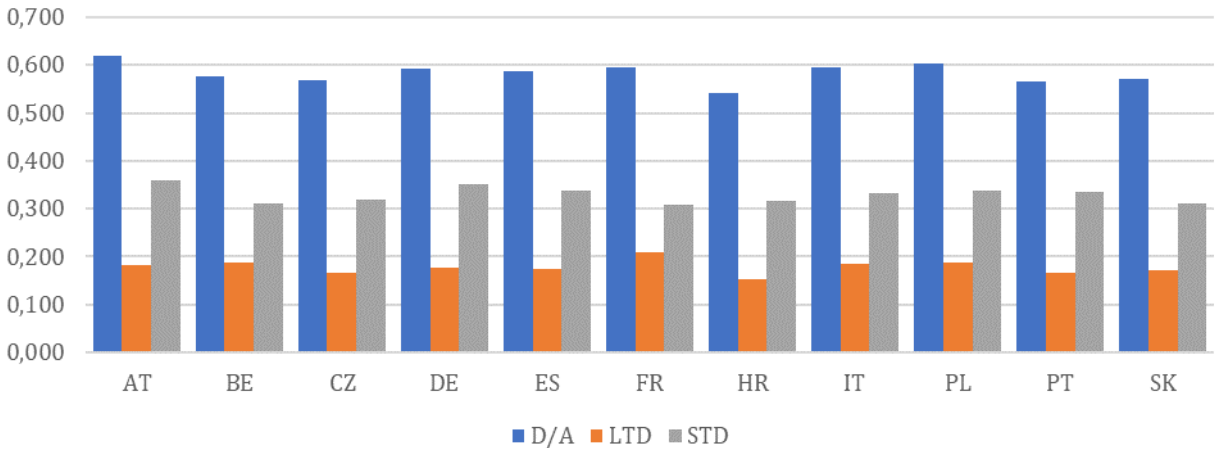

Figure 1. Mean values of debt ratios in the agricultural sector across countries

Note: The mean values are calculated for all size groups of firms (small, medium and large) and for all years available for a given country in the period 2000–2020.
Source: authors' calculations based on BACH (2023).

Table 5. One-way ANOVA results with the grouping factor as the classification of country as the CEE or WE EU member; values of F statistics and p-value in parentheses

Size	Dependent variable		
	D/A	LTD	STD
SMALL	**15.48 (0.000)**	0.423 (0.516)	**4.891 (0.028)**
MEDIUM	**2.774 (0.097)**	**3.068 (0.081)**	2.573 (0.110)
LARGE	0.014 (0.906)	1.112 (0.293)	1.776 (0.184)
All size groups	1.580 (0.209)	**3.331 (0.068)**	0.492 (0.483)

Note: The values of F statistics were bolded for $p < 0.1$.
Source: authors' calculations based on BACH (2023).

Table 6. The verification of research hypothesis H1

Debt ratio	Size class of agricultural firms			
	All sizes	Small	Medium	Large
D/A	H1.1a	H1.2a	H1.3a	H1.4a
LTD	H1.1b	H1.2b	H1.3b	H1.4b
STD	H1.1c	H1.2c	H1.3c	H1.4c

Notes: The shading in the table represents support for the sub-hypothesis.
Source: authors' own compilation.

The examination of the average debt ratio values across different size groups of firms, shown in Figure 2, is more meaningful compared to the international breakdown. The analysis reveals a clear relationship between enterprise size and debt level. The data indicate that the total debt of small enterprises is significantly greater than that of medium and large enterprises. Additionally, small enterprises have considerably more short-term debt than other enterprise groups. Moreover, the level of long-term debt increases with the size of enterprises.

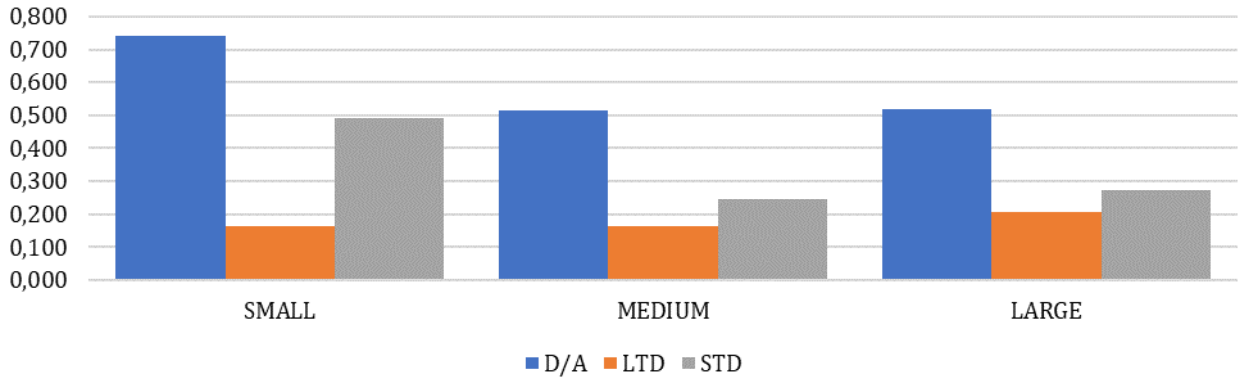

Figure 2. Mean values of debt ratios in the agricultural sector across size groups of firms

Note: The mean values are calculated for 11 countries (AT, BE, CZ, DE, ES, FR, HR, IT, PL, PT, SK) and for all years available for a given country in the period 2000–2020.
Source: authors' calculations based on BACH (2023).

The panel data regression results were utilised to test the second set of research hypotheses for the two groups of EU countries. Tables 7 and 8 display the estimation results of model (1) for CEE and WE EU countries, respectively.

Table 7. Estimation results of panel regressions for Central and Eastern EU countries (CZ, HR, PL, SK)

Variable	Model (1) (D/A)		Model (2) (LTD)		Model (3) (STD)	
	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
const.	0.936***	0.027	0.178***	0.015	0.638***	0.019
TAX	−0.002*	0.001			−0.003**	0.001
TNG	−0.304**	0.100			−0.309***	0.070
DPR	−0.962***	0.285			−1.074***	0.297
ROE	−0.629***	0.189	−0.480***	0.140		
WCR	−0.263***	0.056				
GRA	0.040*	0.018	0.031*	0.014		
RSK			−0.003*	0.002		
M	−0.182***	0.029			−0.189***	0.017
L	−0.181***	0.019			−0.155***	0.009
PL			0.042*	0.022	−0.029**	0.010
SK					0.026**	0.009
No. obs.	105		105		105	
R^2	0.841		0.384		0.845	
Adj. R^2	0.824		0.353		0.834	
AIC	−300.8		−268.6		−296.1	
Hausman test	36.2 [0.000]		6.3 [0.095]		26.3 [0.000]	
Joint significance robust F test						
Size	48.58 [0.000]		N/A		200.13 [0.000]	
Country	N/A		3.82 [0.082]		14.25 [0.002]	

Notes: Interpretation of parameters in relation to small firms and Czechia; * – significant at the 10% level, ** – 5%, *** – 1%.
Source: authors' calculations based on BACH (2023).

As can be seen from Table 7, the factors that significantly influence capital structure formation decisions of agricultural firms in CEE countries are asset structure, non-interest tax shield, profitability, working capital, growth opportunities and risk. In all cases, the direction of influence of these factors indicates that the analysed companies shape their capital structure according to the principles of the pecking-order theory. This means that these companies prefer primarily internal financing, as evidenced by the negative impact of profitability on total and short-term debt. Similarly, the negative relationship between asset structure and debt, both total and short-term, confirms the lower propensity of the companies to take on debt.

Similarly, the negative impact of working capital on total and long-term debt can be explained as these companies strive to maintain high liquidity and thus become independent of debt financing.

On the other hand, the positive relationship between growth opportunities and total and long-term debt means that agricultural firms, having exhausted internal funds, first choose debt financing. This is justified, given the scarcity of capital markets for firms that operate in the agricultural sector. The negative relationship between the non-interest tax shield and total and short-term debt also confirms agricultural firms' preference for debt reduction. Also, risk negatively affects the debt of the surveyed entities, but this relationship is statistically significant only for long-term debt.

Surprising results were obtained for the tax burden, which negatively affects the level of total and short-term debt. This relationship cannot be explained either by pecking-order theory or trade-off theory. The negative impact of the tax burden on the indebtedness of agricultural firms is most likely related to the interventionist policy of the EU and the Member States towards the agricultural sector and to the specific taxation system in agriculture and related tax reliefs. These factors may reduce the propensity for agricultural firms' indebtedness; however, this issue requires further in-depth research.

Another factor that significantly affects indebtedness is the size of the enterprise. Large and medium-sized farms have lower total and short-term debt levels than small farms. The study also confirms the country effect in the capital structure of the entities analysed, although this does not apply to all countries in the group nor to all debt measures.

Table 8. Estimation results of panel regressions for Western EU countries (AT, BE, DE, ES, FR, IT, PT)

Variable	Model (1) (D/A)		Model (2) (LTD)		Model (3) (STD)	
	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
const.	0.824***	0.019	0.116***	0.019	0.671***	0.019
TAX					0.002*	0.001
TNG	−0.215***	0.040	0.090**	0.040	−0.329***	0.042
CSH		0.139	−0.374**	0.139		
DPR		0.286	0.982***	0.286	−1.239***	0.289
ROE	−0.129**	0.054			−0.096***	0.015
WCR	−0.107*	0.055				
GRA			−0.020*	0.011		
RSK	−0.001***	0.000	−0.001*	0.000		
M	−0.184***	0.021			−0.191***	0.010

Variable	Model (1) (D/A)		Model (2) (LTD)		Model (3) (STD)	
	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
L	−0.197***	0.013	0.036**	0.013	−0.201***	0.012
BE					−0.028***	0.007
ES	−0.020*	0.012			−0.035***	0.012
FR					−0.025*	0.013
PT			−0.044*	0.024	0.024*	0.013
No. obs.	293		293		293	
R^2	0.559		0.354		0.838	
Adj. R^2	0.551		0.335		0.832	
AIC	−739.7		−710.5		−807.6	
Hausman test	75.3 [0.000]		16.1 [0.041]		59.8 [0.000]	
Joint significance robust F test						
Size	283.8 [0.000]		7.65 [0.012]		239.07 [0.000]	
Country	3.07 [0.095]		3.29 [0.085]		10.07 [0.000]	

Notes: Interpretation of parameters in relation to small firms and Austria; * – significant at the 10% level, ** – 5%, *** – 1%.
Source: authors' calculations based on BACH (2023).

Agricultural firms in WE countries shaped their capital structure in a slightly different way than those from CEE countries (Table 8). First of all, a positive effect of the tax burden on financial leverage was found in these entities, although it only concerns short-term debt. This relationship is consistent with the trade-off theory. The asset structure was negatively related to total and short-term debt, i.e. it is in line with the principles of the pecking-order theory. By contrast, a positive relationship was observed between long-term debt and asset structure. This implies that agricultural companies in WE countries increase their long-term debt due to the possibility of establishing collateral on their physical assets, which is in line with the trade-off theory. Additionally, the effect of the non-interest tax shield on their long-term debt is positive, which is not consistent with any of the theories tested. As in CEE, this relationship may be due to EU interventionism applied to agricultural companies.

The direction of the influence of other factors on the capital structure of the analysed companies is in line with the pecking-order theory. Thus, profitability negatively influenced total and short-term debt, i.e. as it did in CEE. A negative relationship was observed between liquidity and long-term debt. Growth opportunities had the same effect on this category. Working capital was negatively related to total debt. Risk, on the other hand, had a negative impact on both total and long-term debt.

Company size was also a factor that significantly influenced the amount of debt in WE agricultural firms. Both medium-sized and large firms exhibited lower leverage than small firms. The same pattern applied to short-term debt. Similar patterns occurred in agricultural companies in CEE. Only large WE agricultural firms had more long-term debt than small firms.

The WE country group also saw a statistically significant country effect. However, as in CEE, it only applied to certain countries and debt measures. The assessment of the estimation results for the two country groups leads to the conclusions that are concisely summarised in Table 9.

Table 9. Comparison of the impact of variables on capital structure between CEE and WE countries

Variable	Impact on capital structure		
	Total debt	Long-term debt	Short-term debt
Tax burden (TAX)	slightly different	similar	very different
Asset tangibility (TNG)	similar	slightly different	similar
Financial liquidity (CSH)	similar	slightly different	similar
Deprecation (DPR)	slightly different	slightly different	similar
Profitability (ROE)	similar	slightly different	slightly different
Working capital (WCR)	similar	similar	similar
Firm growth (GRA)	slightly different	very different	similar
Risk (RSK)	slightly different	similar	similar
Size effect (SIZE)	similar	different	similar
Country effect (CT)	different	similar	similar
Year effect (YEAR)	different	similar	similar

Notes: If the impact of a variable was significant for both groups of countries but in opposite directions, it was interpreted as a "very different" impact. If the impact was significant in one group but insignificant in the other group, it was interpreted as a "slightly different" impact. If a variable had the same sign and significance or was insignificant in both groups, it was interpreted as a "similar" impact. Regarding the size, country and year effect, the impact was interpreted as similar if the effect was significant or insignificant in both groups of countries. If the significance differed between the two groups of countries, the effect was considered "different".
Source: authors' own compilation.

Table 9 also provides information about the level of support for the research hypotheses regarding the diversity of impact of various factors on debt between the CEE and WE countries. For the tax burden variable, strong support was found for short-term debt, weak support for total debt, but no support for long-term debt. Regarding asset tangibility and financial liquidity, only weak support was found for long-term debt. The impact of non-debt tax shields on total and long-term debt differs slightly between

the two groups of countries, providing weak support for these two debt measures. In the case of profitability, slight differences in its impact on debt occur when long-term and short-term debt are considered, thus providing weak support here. Working capital is the only variable for which no support was found for any debt measure. The impact of the ratio is significantly negative for both groups of countries, but only for total debt. Regarding firm growth, weak support was found for total debt, strong support for total debt, and no support for short-term debt, as the asset growth proved insignificant for short-term debt regardless of which group of countries was considered. Regarding the risk variable, only weak support can be found in the case of total debt. The size effect shows different intensity levels for long-term debt between CEE and WE countries, whereas the country and year effect proved different in the case of total debt only. Table 10 summarises the verification of research hypotheses H2.

Table 10. Verification of research hypothesis H2 concerning the diverse impact of various factors on debt between CEE and WE countries

Debt ratio	Independent variables										
	TAX	TNG	LIQ	DPR	ROE	WCR	GRT	RSK	SIZE	CT	YEAR
D/A	H2.1a	H2.2a	H2.3a	H2.4a	H2.5a	H2.6a	H2.7a	H2.8a	H2.9a	**H2.10a**	**H2.11a**
LTD	H2.1b	H2.2b	H2.3b	H2.4b	H2.5b	H2.6b	**H2.7b**	H2.8b	**H2.9b**	H2.10b	H2.11b
STD	**H2.1c**	H2.2c	H2.3c	H2.4c	H2.5c	H2.6c	H2.7c	H2.8c	H2.9c	H2.10c	H2.11c

Notes: The shading in the table represents weak support for the hypotheses, while bolding indicates support, and both shading and bolding together indicate strong support.
Source: authors' own compilation.

In general, it can be inferred that differences in the effect of capital structure determinants on debt between CEE and WE countries exist, although they are not particularly striking.

Conclusions

The primary objective of this article was to evaluate how certain factors influence the capital structure of agricultural companies in Central and Eastern European (CEE) nations compared to Western European (WE) nations. It also sought to ascertain whether those firms base their financial choices on the trade-off theory or the pecking-order theory. Given the limited existing research on this subject, the article also aimed to bridge this gap in the academic literature.

The capital structure of CEE agribusinesses is formed based on the principles of the pecking-order theory. This is evidenced by the direction of the effect that all the variables

studied had on the leverage level of these businesses. Similar regularities were found in WE countries, with a positive relationship between tax burden and asset structure and debt, partially confirming the trade-off theory. Notably, the direction of the effect of tax burden on leverage was negative for agricultural firms from CEE. In contrast, there was a positive relationship between non-interest tax shields and long-term debt in WE countries. Due to the unique nature of agriculture, these results are unusual and cannot be explained by any of the theories tested. These links may be due to the interventionist policy of the EU and the Member States regarding agriculture, the unique taxation system in this sector, and the associated tax concessions.

Limited research has been conducted on the capital structure of agricultural companies in the existing scholarly literature. Hence, the outcomes of our analysis constitute a significant addition to the ongoing discourse surrounding the financial choices made by agricultural enterprises.

Overall, our findings provide only partial support for the research hypotheses concerning the diversity of capital structure and its determinants among agricultural firms in CEE vs WE countries. The effect of a firm's location on its debt structure varies depending on firm size and debt type. Similarly, the differences in the impact of individual factors on debt ratios do not apply equally to all factors or all debt maturities. These findings can have implications for policymakers and investors, as they highlight the need to consider firm size and debt maturity when evaluating the impact of location on firm financing in the agricultural sector.

In summary, two main conclusions can be drawn from this research. First, both CEE and WE agricultural enterprises show a preference for internal financing, which is consistent with the assumptions of the pecking-order theory. Moreover, this conclusion is in line with previous global research on the formation of capital structure in agricultural firms. Secondly, a statistically significant country effect was confirmed for some debt measures only. This is due to the specifics of agricultural activity and the impact of regulations that result from the EU's Common Agricultural Policy. The cross-country and cross-regional differences are likely to decrease in the long term, paving the way for further research in this area.

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Analiza porównawcza czynników struktury kapitału przedsiębiorstw rolnych w krajach Europy Środkowo-Wschodniej i Zachodniej UE

Celem artykułu jest porównanie wpływu określonych czynników na strukturę kapitału przedsiębiorstw rolnych w Europie Środkowo-Wschodniej i Zachodniej. Ze względu na specyficzne cechy finansowania gospodarstw rolnych, a także odmienności ekonomiczne i historyczne między badanymi regionami, polityka finansowania przedsiębiorstw w tym sektorze stanowi ważny temat badawczy. Analizą objęto dane finansowe przedsiębiorstw rolnych z dwunastu krajów UE w latach 2000–2020, pozyskane z bazy danych BACH-ESD. Główną metodą zastosowaną w badaniu jest modelowanie panelowe przeprowadzone oddzielnie dla dwóch grup krajów. Wyniki wskazują, że choć nie ma znaczących różnic między krajami w strukturze kapitału, wpływ poszczególnych czynników różni się między badanymi makroregionami. Prezentowana w niniejszym opracowaniu analiza porównawcza dostarcza wartościowych informacji dla ustawodawców, instytucji finansowych i przedsiębiorstw rolnych zarówno w krajach Europy Środkowo-Wschodniej, jak i Zachodniej. Zrozumienie różnic w zakresie czynników struktury kapitału specyficznych dla każdego z badanych regionów może pomóc lepiej ukształtować i podnieść skuteczność polityki finansowania rolnictwa. Ponadto zaleca się, aby decyzje finansowe przedsiębiorstw rolnych uwzględniały czynniki specyficzne dla regionu. Badania wnoszą wkład do istniejącej literatury, rzucając światło na różnice i podobieństwa w determinantach struktury kapitałowej przedsiębiorstw rolnych w Europie Środkowo-Wschodniej i Zachodniej. Analiza nie tylko pogłębia wiedzę na temat różnic między strategiami finansowania w poszczególnych regionach, ale także podkreśla znaczenie specyfiki finansowania przedsiębiorstw rolnych. Dzięki temu badanie to wnosi istotną wartość dodaną w zakresie finansowania rolnictwa i stanowi podstawę do podejmowania bardziej świadomych decyzji w tym sektorze.

Słowa kluczowe: teoria hierarchii finansowania, teoria substytucji, gospodarstwa rolne, dźwignia finansowa, finansowanie przedsiębiorstw rolnych