ISSN 1644-0757
eISSN 2450-047X

ACTA SCIENTIARUM POLONORUM

Czasopismo naukowe założone w 2001 roku przez polskie uczelnie rolnicze
Scientific Journal established in 2001 by Polish Life Sciences Universities

Oeconomia

Economics

Ekonomia

23 (2) 2024

April–June

Bydgoszcz Kraków Lublin Olsztyn
Poznań Siedlce Szczecin Warszawa Wrocław

The printed version of Acta Scientiarum Polonorum Oeconomia is an initial version of the journal

Editorial staff

Dominika Cichocka (copyediting), Lena Maminajszwili (typesetting)

ISSN 1644-0757
eISSN 2450-047X

Warsaw University of Life Sciences Press, Nowoursynowska 161, 02-787 Warsaw
tel. 22 593 55 23
e-mail: wydawnictwo@sggw.edu.pl
www.wydawnictwosggw.pl

Wydawnictwo SGGW

wydawnictwosggw

From the Scientific Board

The Acta Scientiarum Polonorum. Oeconomia has proudly entered its twenty-third year of publication. Founded by a group of passionate enthusiasts, scientists affiliated with Polish life sciences universities, the Acta Scientiarum Polonorum series have received the patronage of rectors of these universities since their inception. This periodical encompasses various thematic series, all characterized by uniform graphics and a consistent format. Constant involvement of academic society in increasing substantive and editorial level of the series, with efforts of the authors, the Programming Board and the Scientific Boards, has contributed to placing the Acta Scientiarum Polonorum (and our Oeconomia series) on the noticeable position in academic research society. Articles are published in English with Polish title, abstract and keywords. The Scientific Board of the Oeconomia series, concerning the publication range, focuses its attention both on substantive content and precision of the form. The articles are revised in "double-blind review" process. Whole content of the Acta Scientiarum Polonorum. Oeconomia is available in electronic version on the following website: https://aspe.sggw.edu.pl/. We are glad to inform that Acta Scientiarum Polonorum. Oeconomia is indexed within the DOAJ, CEEOL, AGRO, Index Copernicus, Baz Ekon, EBSCO, Arianta and PBN.

Please send papers using the publishing system via the link below:
https://aspe.sggw.edu.pl

Yours sincerely
Mariusz Maciejczak
Chairperson of the Scientific Board
of the Acta Scientiarum Polonorum Oeconomia

Acta Sci. Pol.
Oeconomia 23 (2) 2024, 5–16
acta_oeconomia.sggw.pl ISSN 1644-0757 eISSN 2450-047X DOI: 10.22630/ASPE.2024.23.2.5

ORIGINAL PAPER

Received: 13.07.2023
Accepted: 29.03.2024

INFLATION VS INFLATION EXPECTATIONS IN 2020–2021 – THE IMPACT OF THE COVID-19 PANDEMIC

Maria Dunin-Wąsowicz✉

European Movement Forum, Poland

ABSTRACT

Aim: During the COVID-19 pandemic in 2020–2021, there was a significant increase in inflation and inflation expectations due to the government policies of the United States (US) and the European Union (EU), including the Euro Area (EA). With that being said, the evolving situation within these three political-economic areas highlights the importance of understanding the relationship between inflation and inflation expectations, as perceived by both consumers and professional forecasters. The purpose of this article is to analyze the changes in these phenomena, using descriptive survey' data analysis and a hybrid model of inflation expectations. **Methods:** The research methods refer to the descriptive survey data analysis that provides evidence on the long-term courses of inflation in the US, the EU, and the EA, as well as the consumers' and professional forecasters' inflation expectations within the period 1999–2019. A hybrid model of inflation expectations has been used to estimate this data during the period of 2021. The study correlates and compares the findings of both types of research. **Results:** The results demonstrate that during the pandemic, the evidence supports the occurrence of periodic medium-high inflation in the studied economic areas. Inflation expectations in the US and the EU were periodically weakly anchored, although they were stabilized in the EA. **Conclusions:** The research, conducted by analyzing price trends and their expected trajectories over various timeframes, revealed consistent patterns. These patterns highlighted similarities in anticipated price changes before and during the pandemic.

Key words: inflation, inflation expectations, pandemic, long-term, short-term

JEL codes: B30, C00, E31

INTRODUCTION

At the end of the second decade of the 21st century, economists characterized it as an era of global stability, marked by an average inflation rate of approximately 3.36% [IMF 2021] from 1970 to 2020. The outbreak of the coronavirus pandemic destroyed this stability. The evolving state of play in the United States (US), the European Union (EU), and the Euro Area (EA) during the pandemic highlights the prominence of understanding the interrelation between inflation and inflation expectations observed by both consumers and professional forecasters. Accordingly, three basic research questions should be answered: 1) how quickly inflation will proceed, taking into account the governments' decisions in 2020–2021 to stimulate the observed economies; 2) how these pro-inflationary measures condition inflation expectations formulated

Maria Dunin-Wąsowicz https://orcid.org/0000-0003-0155-258X
✉ maria.duninwasowicz@gmail.com

by consumers' and professional forecasters; 3) what are the impacts of these appearances considered in maintaining the anchored inflation expectations? The main contribution of this analysis is to adopt an approach that aims to verify the thesis that governmental justifications for stimulating the economy to fight against the disease have impacted changes in the pace of inflation and inflation expectations.

The paper is organized into four sections. The first section examines inflation theories in relation to the studies of inflation expectations. The second part delves into the relationship between inflation speed and inflation expectations, covering the long-term period from 1999 to 2019 in the US, the EU, and the EA, along with the COVID-19 pandemic period from 2020 to 2021. The third chapter presents a hybrid model of inflation expectations while demonstrating the outcomes of the distinctive situations in selected political areas. The fourth section outlines modeled inflation expectations in the US, the EU, and the EA. The article concludes with findings.

RELATED LITERATURE

One of the first debates on macroeconomic inflation theories in the context of inflation expectations' formation brought agreement that "future behavior is dominant in the analysis of expected inflation dynamics", since it has an impact on decisions that determine the current inflation [Muth 1961, Gertler et al. 2001, D'Acunto et al. 2020, Rogoff 2021]. This is how John M. Keynes [1936] defined this phenomenon, also indicating that expectations – divided into short- and long-term – impact the amount of output, employment, and savings [Łyziak 2011]. Nevertheless, research notes many approaches, including the monetarist [Phelps 1967, Friedman 1968], which suggested that inflation expectations could be modeled adaptively (Adaptive Expectations – AE). Indeed, the concept of rational expectations (RE) was proposed by the Nobel Prize recipient Robert B. Lucas [1972], who was followed by the New Keynesians [Evans and Honkapohja 2002], demonstrating that expectations should be perceived as based on optimality (BO). In turn, Charles F. Manski [2004] found out that forecasters are forced to form probabilistic expectations (PE), while – according to Christopher A. Sims [2008] – expectations should be perceived as a research view with limited rationality (LR). Built at the end of the second decade of the 21st century, the diagnostic expectations concept (DE) says that each forecaster reacts only according to their own assessments [Bordalo et al. 2019]. Recent years have brought the idea of Richard Curtin of tailored expectations (TE). It has been proved that consumers should be treated equally with businesses and the government as having an independent and visible impact on the macro-economy, while observing a close correspondence between aggregate trends in consumer expectations and such trends in national statistics [Curtin 2019, Curtin 2022]. Still, contemporary economists are inclined to the thesis that none of the proposed options fully meet the criterion of expecting the rate of future inflation. One might note (a little jokingly) that the options developed inform us about expectations from the past and not about the expectations to come. At the same time, it has been proven that economic and financial decisions of households and firms – such as consumption, investment, price, and wage setting – formed as inflation expectations' surveys can have an impact on actual inflation [Łyziak et al. 2018, Rogoff 2021, Schnabel 2021, Schafer 2022]. So, it can be said that these expectations shaped in the aftermath of the pandemic are both rational (LR) but also adaptive to some extent (AE). In short, fiscal policy is not responsible for inflation, though it occurs if the government increases their debts [Friedman 1968, Cochrane 2021], contrary to people's expectations. Furthermore, it can also be said that assessments of inflation sources – and consequently, its definition – can be modified as a result of COVID-19 [Banaszyk et al. 2021, Rudd 2021].

INFLATION AND ITS EXPECTATIONS. A LONG-TERM PERSPECTIVE

This section provides evidence on the long-term courses of inflation in the US, the EU, and the EA, as well as the inflation expectations of consumers' and professional forecasters' within the period 1999–2019.

Government decisions to stimulate fiscal policy were applied in the examined areas respectively in the years 1999–2001 (dot-com bubble [Galbraith and Hale 2004]), in 2005–2012 (consisting of important stages such as the pre-crisis 2005–2007, crisis 2008, post-crisis 2009–2012), and in 2016–2018 (doubts about governments); (Fig. 1).

As a result, an increase in the inflation rate has been observed both in the US, the EU, and in the EA. Indeed, the status quo does not change even if we assume that the Eurostat data for 2022 taken for the study pertain to the level of inflation in the EU and the EA [ECB 2022 and Eurostat 2022a]. If we simultaneously consider the results of consumer surveys on inflation expectations in the mentioned areas (Fig. 2–4) and combine them with inflation levels from 1999 to 2019, one can notice that lower inflation levels were associated with lower indicators of these expectations, and vice versa. Higher inflation was accompanied by increased indicators of expectations in the analyzed areas. To sum up, public expectations became unstable as governments intensified their fiscal involvement [MICH 2021 and Yellen 2016].

As we can see in Fig. 3, surveys collected by the European Commission since May 2003 on consumers' aggregated inflation perceptions (CES) show that inflation expectations in the EU exhibited instability during and after macroeconomic shocks, specifically during the 2008 financial crisis and throughout the period from 2010 to 2012 [ECB 2013]. The course of expectations in the Euro Area (Fig. 4) looked different than in the EU during the comparable re-

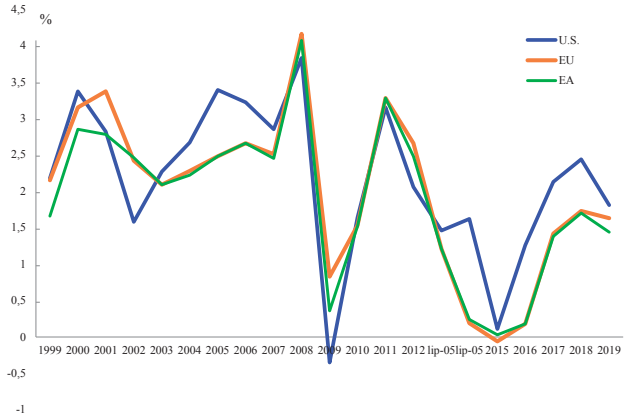


Fig. 1. Inflation in the US, the EU, and the EA in 1999–2019 [%]
Source: own elaboration based on OECD, Eurostat, and FRED data.

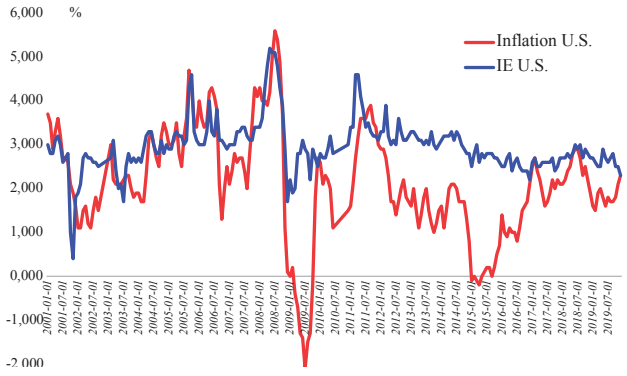


Fig. 2. Inflation and inflation expectations in the US (monthly) in 2001–2019 [%]
Source: own elaboration based on MICH and BLS.

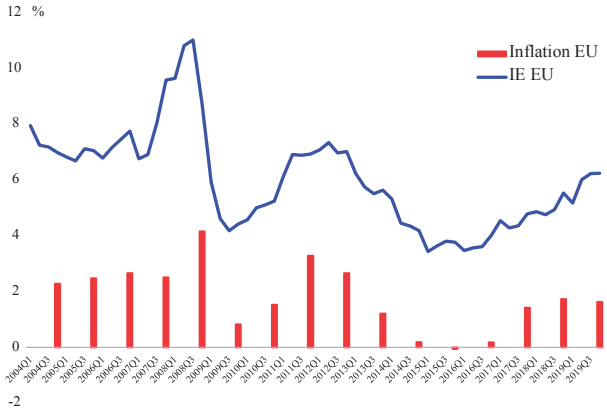


Fig 3. Inflation (p.a.) and inflation expectations (quarterly) in the EU in 2004–2019 [%]
Source: own elaboration based on European Commission and Eurostat.

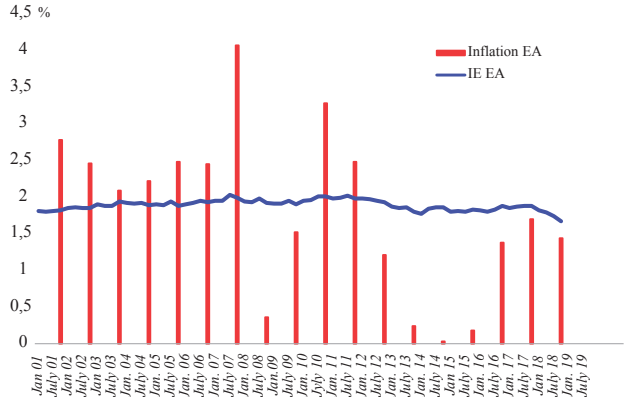


Fig. 4. Inflation (p.a.) and inflation expectations (quarterly) in the EA in 2001–2019 [%]
Source: own elaboration based on EBC data.

search period (2001–2019). Above all, appropriate research began to be carried out soon after the creation of EA, i.e., in this case, from 2001. Moreover, it was found that the expectations have been anchored since its start around the ECB's inflation target [ECB 2011].

INSTITUTIONAL INFLATION, ITS EXPECTATIONS, AND THE PANDEMIC

Given the above insights, I will therefore expand on the long-term inflationary phenomena referred to as episodes that occurred during the pandemic. Accordingly, one should ask: what factors conditioned the price dynamics in the US, the EU, and the EA, and what was the course of both inflation and inflation expectations in the analyzed period?

I'll first delineate the influence of the respective governments, which undertook their policies in two stages in response to the pandemic, also in accordance with the suggestions of international institutions [OECD/European Union 2020, IMF 2022]. The early stage essentially started in mid-March 2020. It was at this time that governments introduced lockdowns in response to the course and consequences of the medical crisis. However, these decisions soon resulted in a halt in production, subsequently leading to a growth in unemployment, a drop in consumption, an increase in consumers' savings (as a percentage of their income), and a decline in businesses' investment

commitments, while generating a rapid increase in prices starting from April 2020. The restrictions on the functioning of economies during the second period of the pandemic, throughout 2021, caused a number of shortages in specific sectors, leading to price pressure, particularly on food and energy. The observed turmoil had a severely adverse impact on the economy. Even though the US inflation rate in 2020 was 1.4%, which was lower than in the preceding year (by 0.9 percentage points), by the end of 2021 it had already reached a level of 7.036%, not seen since June 1982 when it was 7.064% [IMF 1986]. At the same time, the rate of inflation in the EU, which was approximately at an average level of 0.49% in 2020, reached 5% a year later. Inflation in the EA in December 2021 was 5%, while at the end of 2019 it was 0.29% (Fig. 5).

Such indicated macroeconomic factors, understood as a derived consequence of the government's decision to implement fiscal stimulus, were the primary reason for the rapid increase in inflation in both the US and the EU, including in the EA. Therefore, it can be referred to as institutional, or even government-induced inflation. Furthermore, when supplementing the data from 1999–2019 (Fig. 1) with the changes observed from 2020 to 2021 (Fig. 3), we can observe that the rate of growth in this institutional inflation and its magnitude during the latter period are significantly higher – twice on average – than the rate and magnitude of inflation in the twenty years prior to the pandemic [Eurostat 2022a].

I will now delve into the topic of institutional inflationary factors and inflation expectations in the US. In response to the pandemic, which afflicted over 79 million people and claimed the lives of over 967,600 individuals, both the Donald Trump and Joe Biden administrations allocated approximately USD 5.12 trillion in special funds to combat the disease [CAA 2020, CRS 2020]. However, despite this substantial spending on pandemic-related measures, inflation in the economy did not experience a significant increase in 2020 [CARES 2020, CPRSA 2020]. Experts attributed this phenomenon to the well--entrenched practice of households actively working to minimize their expenditures. Ultimately, the continuous price fluctuations observed in early 2021 were mirrored by a decline in public sentiment, as evident in surveys measuring inflation expectations [Labonte et al. 2021]; (Fig. 6).

As a consequence, the graph shows that inflation expectations of professional forecasters were broadly anchored around the 1.6% average level, though there was a short period of radical destabilization reaching the deflation level of –0.8% in May' 2020. These expectations dropped drastically from 2.2% in March to –2.3% in June, before returning to the average level of approximately 2% in September of that year [US Bureau of Labor Statistics 2020–2021]. The severity of the pandemic in the EU, including the EA perspective, was even greater than in the US. The

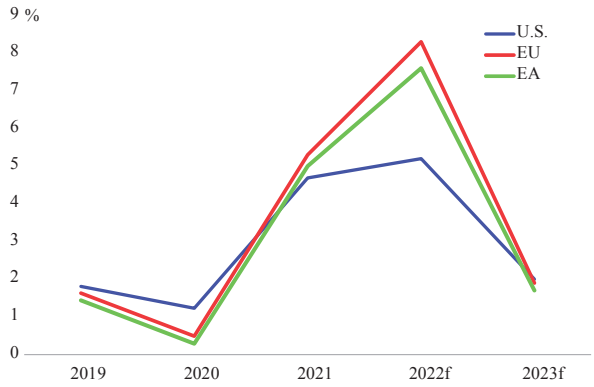
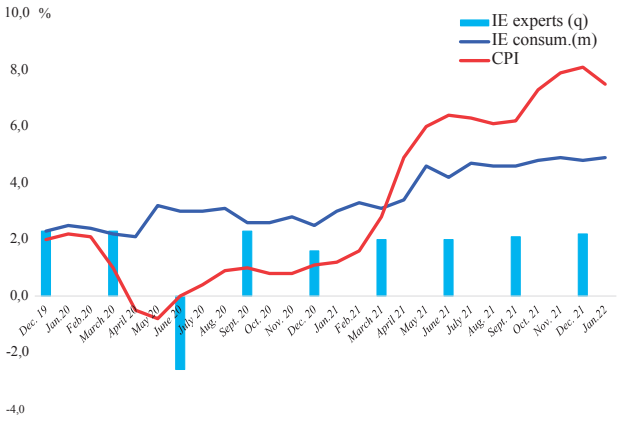


Fig. 5. Inflation in the US, the EU, and the EA in 2019–2023 [%]
Source: own elaboration based on OECD, IMF, and FRED data.



ie experts (q) – quarterly; ie consumers (m) – monthly

Fig. 6. Inflation and inflation expectations (consumers & experts) in the US, 2020–2021 [%]

Source: own elaboration based on BLS, FED, and MICH data.

course of the pandemic in the EU, where approximately 100 million cases of COVID-19 were recorded from January 2020 until the end of 2021 [WHO 2022], displayed similar characteristics to the developments in the US. Rapid decisions on the implementation of fiscal stimulus were taken by both the EU governments and the EU institutions, injecting 1,824.3 billion euros into the European economy. As expected, EC data (HICP) quickly revealed the problems caused by rapid price rises. Countries that were under the influence of the USSR prior to 1990, such as Poland, Hungary, or Estonia, experienced the most significant impact from this phenomenon [GUS 2022, Eurostat 2022a, Eurostat 2022b]. Nevertheless, the issues stemming from the pandemic were responsible for inflation across the EU during that period. This is why the European Commission, responsible for conducting consumer surveys on inflation expectations, determined that there would be a rapid and substantial increase in inflation in 2020–2021 based on this data. The EU's inflation expectations, which stood at a relatively high level of 6.59% in 2020 despite a relatively low inflation rate of 1.23%, made for a noteworthy forecast [ECB 2022]. However, this forecast was not confirmed by subsequent changes in the expectations index one year later, which dropped to 4.57% after a period from January to September 2021 characterized by low inflation expectations at 2.8%, despite an average inflation rate of approximately 2.9% (Fig. 7).

Conversely, it can be inferred that the unsettled consumer inflation expectations (CE) within the EU during 2020–2021 may have signaled an expected rise in inflation. This anticipation could have arisen from survey respondents adjusting their medium-term inflation expectations based on their personal perception of inflation [Stanisławska and Paloviita 2021]. Such a process had also been observed within the EA, where the average inflation expectations index was approximately 1.69% in 2020, with a slight uptick to 1.82–1.9% during the latter half of 2021. Furthermore, the rise in inflation within the EA to a level of 5% in December 2021 could serve as confirmation of the validity of the post-pandemic inflation hypothesis.

THE MODEL OF INFLATION EXPECTATIONS

This section relies on data from the previously mentioned quantitative questions to explore how consumers in the US, EU, and EA shape their inflation expectations. To do this, a hybrid model of inflation expectations has been used for data estimation, as described below:

$$\pi t^{e} = c + \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t+12} + \varepsilon_t \quad (1)$$

where:

πt^{e} – expected inflation in period t after 12 months,

π_{t+12} – inflation CPI (*y*/*y*) in period $t + 12$,

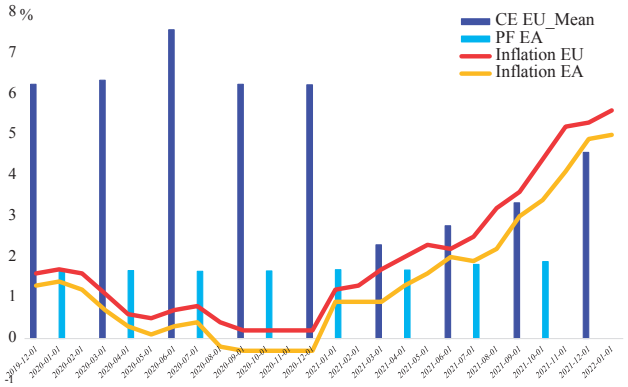


Fig. 7. Inflation (monthly) and consumers' inflation expectations in the EU experts' surveys quarterly in EA, 2020–2021 [%]
Source: own elaboration based on EC, Eurostat, and ECB data.

π_{t-1} – inflation CPI (*y/y*) in a one month preceding the month of carrying out of survey,
ε_t – 0%.

The model presented above is estimated on aggregated data – received from consumers' surveys carried out in each area respectively – to assess its impact on the average of the set of individual answers to Questions 2 and 3. The model consists of elements of adaptative expectations (AE) and elements of rational expectations (RE). When $c = \alpha_1 = 0$ and $\alpha_2 = 1$, the model meets the condition of forming rational expectations. Moreover, with sum of parameters α_1 and α_2 equals 1, the results of estimation of expected inflation are allowed to be treated twofold:

- in reference to a1 as the effect of examination of consumers' surveys formulating their expectation adaptively;
- in reference to a2 as the outcome of examination of consumers' surveys formulating anticipation-oriented expectation.

At the same time, the average expected inflation should be compared with the rate of inflation in line with the expectations' horizon in 12 months. In order to carry out the analysis under the above assumptions, I have made a decile breakdown of the distributions of expected inflation by month and then assessed the dynamics of these statistics within the accepted time [US Bureau of Labor Statistics 2020–2021]. It is noted that the answer is considered inconsistent if the consumer answering the qualitative question (1) states that prices will rise faster than at present, while declaring lower expected inflation than perceived inflation in response to quantitative questions (2–3). This inconsistency can be ruled out by introducing a sensitivity interval of 2ε. If the difference between perceived and expected inflation is less than +/–ε, such inconsistency is considered of no research significance [EC 2020]. Since consumers used to treat as insignificant some slight deviation of the inflation level from its actual level, the expected inflation was estimated on the assumption of five sensitivity ranges: mean, 0 p.p. and ranges +/–1 p.p., +/–3 p.p., and +/–5 p.p.

MODELLED INFLATION EXPECTATIONS VS QUANTITATIVE QUESTIONS

The analysis of the distribution of modeled individual responses in the US, obtained on the basis of equation (2), with regard to the level of expected inflation in the years 2020–2021, allows for the following conclusions. Firstly, simulation results indicate that the inflation expectations of respondents in the US were in the range of 2.2–8.1% (Fig. 8).

However, in the short term, they fell to around –0.8%, well below the inflation target, but in line with the current inflation level. Concurrently, in some periods, modeled expectations have largely stabilized at levels close to the inflation rate. Thus, during the period of December 2019–March 2020, inflation expectations were stable, remaining at around 2.2%, 2.1%, and 2.3%, on average exceeding the then Fed's

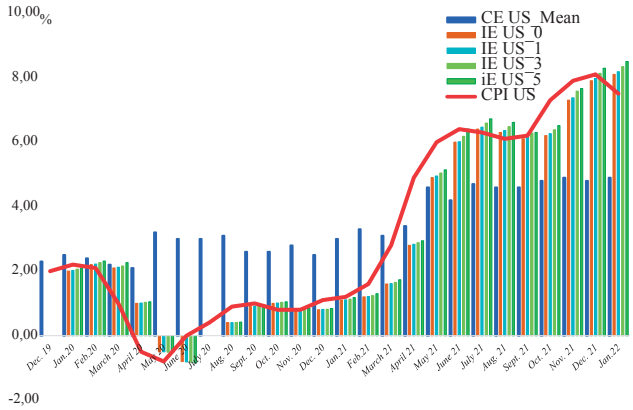


Fig. 8. Modeled inflation consumer expectations in the US in 2020–2021 [%]
Source: own elaboration based on FRED data.

1.29% inflation target by 1 p.p. As mentioned earlier, inflation in the US remained stable throughout 2020, with a temporary dip below zero occurring from April to June 2020. It was only at the beginning of 2021 that a noticeable shift in consumer attitudes became apparent. Following the adjustment period in the fall of 2020, where consumers' inflation expectations aligned with the actual level, there was a subsequent period from December 2020 to May 2021 where an underestimation of the inflation level ranging from 0.24 to 0.8 percentage points was observed. It was not until June 2021 that inflation expectations started to increase, aligning with the actual inflation rate of around 8.1% by December 2021 [BLS 2021 and IMF 2021]. In summary, inflation expectations in the US can be characterized as adaptive (AE).

The disparity in modeled inflation expectations within the EU, as opposed to the more synchronized distribution of consumer expectations in the US over the examined period, can be attributed to the emergence of inflationary conditions in an environment that had maintained a low inflation rate, usually not exceeding approximately 1.89%, for the past two decades [Eurostat 2022b]. Therefore, the change in the attitude of the EU institutions to fiscal policy, although justified by the pandemic, has resulted in high inflation expectations that periodically exceed the level of real inflation by ten times. Expectations modeled in June 2020 were 0.5–0.53%, while average consumer expectations in the same month, according to Eurostat data, reached 7.58%. In 2020, the level of inflation in the EU remained at an average annual level of 0.68%, while a year later it increased to 2.43%, exceeding the annual forecasted value of 1.5% by more than 0.9 p.p. Inflation expectations were, therefore, destabilized – although the expectations index was already high in December 2019 at 6.24% under the rate of inflation at 1.6%, while in March 2020 it reached 6.34%. The highest level of expectations occurred in June 2020, reaching the rate of 7.58% with the rate of inflation of 0.7%. In November, the level of expectations was reduced to 6.23% when the current level of inflation stood at 0.2% (Fig. 9).

Certainly, the notable drop in inflation expectations in 2021 to an average of 3.24% during the first three quarters was mainly a result of the EU institutions scaling down their financing efforts related to COVID-19. Subsequently, these modeled inflation expectations underwent a swift ascent, reaching levels of 5.3 to 5.6% by December 2021. Generally, the modeled inflation expectations of consumers in the EU in the years 2020–2021 exhibited fluctuations that hovered around the quarterly average value derived from EC research. The maximum divergence index was approximately 0.1 pp in the period August–December 2021, when the average level of inflation expectations recorded by the EC was 3.95%, while the average rate of modeled consumer inflation expectations had been estimated at 3.85% (with the average inflation level of 4.03%). The distributions of the

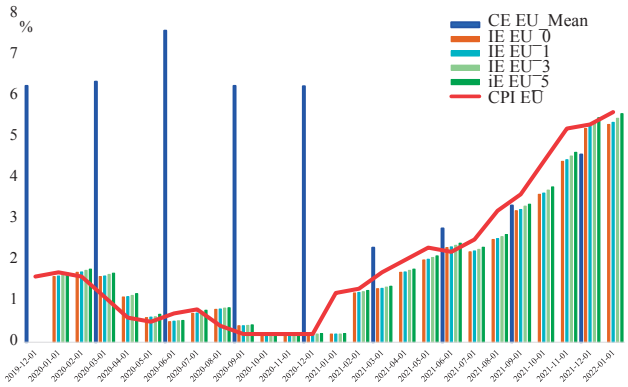


Fig. 9. Modeled inflation consumer expectations in the EU in 2020–2021

Source: own elaboration based on EC and Eurostat data.

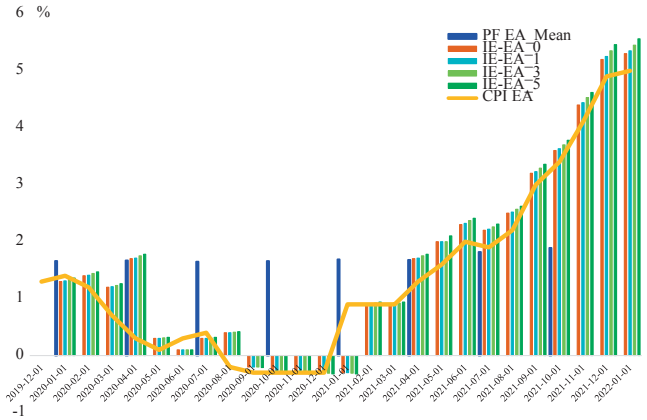


Fig. 10. Modeled inflation expectations in EA in 2020–2021[%]

Source: elaboration based on [EBC 2022].

modeled expected inflation were left-skewed, except for the months of September-October 2020, when the observed distribution was horizontally aligned. The average value of the inflation expectations index was approximately 1.69% in the EA in 2021–2022, while it remained at a mean yearly level of 0.3% in 2020, and at 2.25% in 2021 [ECB 2021]. The course of expectations therefore indicated their relative destabilization. The results of the inflation expectations estimation validate its occurrence during the period from February 2020 to October 2021, wherein the average discrepancy between the quarterly average expected inflation and the average modeled expected inflation was approximately 0.982 percentage points (Fig. 10). Inflation expectations remained relatively stable in January 2020, as well as from September to December 2020 and during the months of February to March 2021. In summary, inflation expectations in both the EU and the EA can be categorized, similarly to the US, as adaptive (AE).

CONCLUSIONS

The empirical evidence presented in this study points to the following conclusions. As observed, pandemic inflation occurred in the US and in the EU, including the EA, after a long period of low prices. The substantial government involvement in financing the economy during various lockdowns has notably and significantly disrupted inflation expectations in the economic areas mentioned, serving as an indicator of inflation, which has already gained high dynamics

in 2021. The rapid increase in these indicators demonstrates that institutions responsible for monitoring inflation have not sufficiently studied them, thereby constituting a significant limitation for observers. In the meantime, through the analysis of price trends and their expectations over various timeframes, the research uncovered consistent patterns, highlighting similarities between anticipated price changes before and during the pandemic. Firstly, the tension between inflation expectations and inflation dynamics during the pandemic period shall be seen as a kind of warning against classifying inflation as a process independent of institutional conditions, such as anti-COVID decisions taken both by the US, the EU, including the EA. On the contrary, such a form of inflation can be linked to government fiscal stimulus, although it exhibits a lag of approximately 12 months. Essentially, this type of inflation caused by government institutions can be referred to as institutional inflation or even government-induced inflation. Secondly, such inflation is expected to increase, underscoring the importance of maintaining both stability and alignment with inflation targets. The suggestion is significant because the principle of stability excludes the use of fiscal stimulation, which, however, sometimes has to be implemented. Indeed, fiscal stimulation is correctly perceived in the economy as a source of problems, rather than a tool to strengthen it. And yet, the need to support fiscal stimulus to combat the pandemic highlights the necessity to broaden the scope of assessing the impact of this factor on inflation growth and inflation expectations in such periods of threat to the health of entire communities. Thirdly, the observance of inflation expectations plays a role in shaping trust in both government and central bank objectives. This means that there is a need to evaluate its effects also beyond economic concerns, while prioritizing ethical considerations, with the primary direction being the protection of society from disease, rather than following strict economic norms, especially those related to pandemic fiscal restraint.

REFERENCES

Banaszyk, P., Gorynia, M., Deszczyński, M., Malaga, K. (2021). Przesłanki modyfikacji wybranych koncepcji ekonomicznych na skutek pandemii COVID-19 (The premises for modifying selected economic concepts due to the COVID-19 pandemic). Gospodarka Narodowa, The Polish Journal of Economics, 1, 53–86.

BLS (2021). Statistical data on inflation. Retrieved from https://www.bls.gov/news.release/cpi.toc.htm [accessed: 30.03.2023].

Bordalo, P., Gennaioli, N., La Porta, R., Shleifer, A. (2019). Diagnostic expectations and stock returns. Journal of Finance, 74(6), 2839–2874.

Cochrane, J.H. (2021). The ghost of Christmas inflation. Retrieved from https://www.project-syndicate.org/commentary/us-fiscal-inflation-5-trillion-stimulus-by-john-h-cochrane-2021-12 [accessed: 22.03.2023].

Congressional Research Service/CRS (2020). Overview of U.S. Domestic Response to Coronavirus Disease 2019 (COVID-19), (March 2), 1–26.

Consolidated Appropriations Act of 2021/CAA (2020), H.R.133–116th Congress Public Law 260, 1–134. Retrieved from https://www.congress.gov/116/plaws/publ260/PLAW-116publ260.pdf [accessed: 03.04.2021].

Coronavirus Aid, Relief and Economy Security/CARES Act (2020), Congress.Gov, 1–247. Retrieved from https://www.congress.gov/116/bills/s3548/BILLS-116s3548is.pdf [accessed: 03.04.2021].

Coronavirus Preparedness and Response Supplemental Appropriations/CPRS Act (2020), Congress.gov., 1–157. Retrieved from https://www.congress.gov/116/plaws/publ123/PLAW-116publ123.pdf [accessed: 22.03.2022].

Curtin, R. (2019). Consumer expectations: a new paradigm. Business Economics, 54(4), 199–210.

Curtin, R. (2022). A new theory of expectations. Journal of Business Cycle Research, 18, 239–259. https://doi.org/10.1007/s41549-022-00074-w

D'Acunto, F.D Hoang, D., Weber, M. (2020). Managing Households' Expectations with Unconventional Policies. KIT Working Paper Series in Economics, 148. https://doi.org/10.5445/IR/1000130761

ECB (2011). Annual Report. Retrieved from https://www.ecb.europa.eu//pub/pdf/annrep/ar2011en.pdf [accessed: 30.03.2023].

ECB (2013). Annual Report. Retrieved from https://www.ecb.europa.eu/pub/pdf/annrep/ar2013en.pdf [accessed: 30.03.2023].

ECB (2021). Inflation expectations and their role in Eurosystem forecasting. European Central Bank Occasional Paper Series, 264. Retrieved from https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op264~c8a3ee35b5.en.pdf [accessed: 30.03.2023]

ECB (2022). The Survey of Professional Forecasters for the fourth quarter of 2022. Retrieved from https://www.

ecb.europa.eu/stats/ecb_surveys/survey_of_professional_forecasters/html/ecb.spf2022q4~eb4b9aa2c2.en.html#toc2 [accessed: 14.01.2022].

Eurostat (2022a). Database. Retrieved from https://ec.europa.eu/eurostat/data/database [accessed: 30.03.2023].

Eurostat (2022b). Flash estimate – December 2021, Euroindicators, 7 January. Retrieved from https://ec.europa.eu/eurostat/news/euro-indicators [accessed: 30.03.2023].

European Commission/EC (2020). Reference metadata on methodology and quality. Retrieved from https://economy-finance.ec.europa.eu/system/files/2022-05/reference_metadata_on_methodology_and_quality_for_bcs.pdf [accessed: 30.03.2023].

European Commission/EC (2022). Surveys and data collection in a historical perspective. Retrieved from https://europa.eu/capacity4dev/rnsf-mit/wiki/123-surveys-and-data-collection-historical-perspective [accessed: 30.03.2023].

Evans, G.W., Honkapohja, S. (2002). Expectations and the Stability Problem for Optimal Monetary Policies Commitment. Retrieved from https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/73/UO-2001-6_Evans_Expectations.pdf [accessed: 30.03.2023].

FRED (2022). Economic data. Retrieved from https://fred.stlouisfed.org [accessed: 30.03.2023].

Friedman, M. (1968). The role of monetary policy. The American Economic Review, 58(1), 1911–2019.

Friedman, M. (1994). Intrygujący pieniądz (Intriguing money). Wydawnictwo Łódzkie, Łódź.

Galbraith J.K., Hale, T. (2004). Income Distribution and the Information Technology Bubble. University of Texas Inequality Project Working Paper, 27. Retrieved from https://www.utip.lbj.utexas.edu/papers/utip_27.pdf [accessed: 30.03.2023].

Gertler, G.J., Lopez-Salido, M., David, J. (2001). European inflation dynamics. European Economic Review, 45(7), 1237–1270.

GUS (2022). Wskaźniki cen towarów i usług konsumpcyjnych (Indicators of prices for consumer goods and services). Retrieved from https://bdm.stat.gov.pl [accessed: 14.01.2022].

IMF (2021). World Economic Outlook: Health concerns, supply disruptions, and price pressures, Washington.

IMF (2022). Statististical data. Retrieved from https://www.imf.org/external/datamapper/PCPIPCH@WEO/OEMDC/ADVEC/WEOWORLD [accessed: 30.03.2023].

Keynes, J.M. (1936). The general theory of employment. Interest and money. Macmillan Cambridge University Press. Retrieved from https://www.marxists.org/reference/subject/economics/keynes/general-theory/ [accessed: 30.03.2023].

Labonte, M., Weinstock, L.R (2021). Inflation in the wake of Covid-19. Congressional Research Service Report, R46890. Retrieved from https://crsreports.congress.gov/product/pdf/R/R46890 [accessed: 30.03.2023].

Lucas, R.E. (1972). Expectations and the neutrality of money. Journal of Economic Theory, 4(2), 103–124.

Łyziak, T. (2011). Oczekiwania inflacyjne w Polsce (Inflation expectations in Poland). Narodowy Bank Polski. Retrieved from https://nbp.pl/wp-content/uploads/2023/01/Oczekiwania_inflacyjne_w_Polsce.pdf [accessed: 30.03.2023].

Łyziak, T., Paloviita, M. (2018). On the formation of inflation expectations in turbulent times. The case of the euro area. Economic Modelling, 72, 132–139. https://doi.org/10.1016/j.econmod.2018.01.011

Manski, C.F. (2004). Measuring Expectations. Econometrica, 72(5), 1329–1376.

Muth, J.M. (1961). Rational Expectations and the Theory of Price Movements. Econometrica, 29(3), 315–335.

OECD/European Union (2020). Health at a glance: Europe marks the start of a new State of Health in the EU cycle. OECD Publishing. https://doi.org/10.1787/82129230-en

OECD (2021). Economic outlook. Retrieved from https://www.oecd-library.org [accessed: 30.03.2023].

Phelps, E.S. (1967). Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time. Economica, 34(135), 254–281.

Rogoff, K. (2021). Back to the Seventies?, Project Syndicate. Retrieved from https://www.project-syndicate.org/commentary/america-facing-1970s-style-stagflation-threat-by-kenneth-rogoff-2021-08 [accessed: 30.03.2023].

Rudd, J.B. (2021). Why do we think that inflation expectations matter for inflation? (And should we?), Federal Reserve Board, 062, 1–25.

Schafer, J. (2022). Inflation expectations and their formation. Congressional Budget Office Working Paper, 2022-03, 1–32. Retrieved from https://www.cbo.gov/system/files/2022-03/57398-Inflation.pdf [accessed: 30.03.2023].

Sims, C.A. (2008). Inflation expectations, uncertainty, the Phillips curve and monetary policy. Federal Reserve Bank of Boston, 1–26. Retrieved from http://sims.princeton.edu/yftp/CapeCod2008/Sketch.pdf [accessed: 30.03.2023].

Stanislawska, E., Paloviita, M. (2021). Medium- vs. short-term consumer inflation expectations: evidence from a new euro area survey. Bank of Finland Research Discussion Papers, 10, 1–40. Retrieved from https://www.ecb.europa.eu/pub/conferences/shared/pdf/20211007_inflation/Stanislawska_paper.en.pdf [accessed: 30.03.2023].

University of Michigan/MICH (2021). Surveys of consumers. Retrieved from https://src.isr.umich.edu [accessed: 10.01.2023].

U.S. Bureau of Labour Statistics (2021). Retrieved from https://www.bls.gov/news.release/cpi.toc.htm [accessed: 19.12.2021].

Yellen, J. (2016). Current conditions and the outlook for the U.S. economy. The World Affairs Council of Philadelphia. Retrieved from https://www.federalreserve.gov/newsevents/speech/yellen20160606a.htm [accessed: 30.30.2023].

INFLACJA A OCZEKIWANIA INFLACYJNE W LATACH 2020–2021 – WPŁYW PANDEMII COVID-19

STRESZCZENIE

Cel: Podczas pandemii COVID-19 w okresie lat 2020–2021 nastąpił wysoki wzrost inflacji oraz odpowiednio oczekiwań inflacyjnych w Stanach Zjednoczonych (USA), Unii Europejskiej (UE), a także w strefie euro (EA). Przebieg zmian wskaźników makroekonomicznych we wskazanych trzech obszarach polityczno-gospodarczych USA, UE i EA zwraca uwagę na obecność zależności między dynamiką inflacji a taką dynamiką oczekiwań inflacyjnych. Oba typy zmian charakteryzują zarówno zachowania konsumentów, jak i zachowania grup profesjonalnych prognostów. Celem artykułu jest zbadanie sekwencji zmian obu wskazanych zjawisk zarówno z wykorzystaniem opisowej metody analizy danych ankietowych, jak i w wyniku zastosowania hybrydowego modelu szacowania oczekiwań inflacyjnych. **Metody:** Metodyka badań polega na zastosowaniu techniki opisowej analizy danych w odniesieniu do długoterminowego rozkładu zjawisk inflacji i oczekiwań inflacyjnych obserwowanych wśród konsumentów i profesjonalnych prognostów w USA, UE i EA w latach 1999–2019. Z kolei do oszacowania danych dotyczących zjawiska inflacji oraz oczekiwań inflacyjnych w krótkim okresie 2021 roku wykorzystano hybrydowy model oczekiwań inflacyjnych**.** W opracowaniu zestawiono i porównano wyniki obu typów badań. **Wyniki:** Analizy wskazują, że w czasie pandemii obserwuje się występowanie okresowo średnio-wysokiej inflacji w trzech analizowanych obszarach gospodarczych, podczas gdy jednocześnie oczekiwania inflacyjne w USA i UE były okresowo słabo zakotwiczone, choć jednocześnie odnotowano ich ustabilizowanie w EA. **Wnioski:** Z badań polegających na analizie trendów zmian cenowych oraz zmian oczekiwań inflacyjnych w różnych okresach czasowych – długo- i krótkoterminowych – wynika istnienie zaobserwowanych spójnych wzorców zależności między dynamiką inflacji, a taką dynamiką oczekiwań inflacyjnych również ze względu na występowanie podobieństw w przebiegu obu typów zjawisk przed pandemią oraz w jej trakcie.

Słowa kluczowe: inflacja, oczekiwania inflacyjne, pandemia, długoterminowy, krótkoterminowy

Acta Sci. Pol.
Oeconomia 23 (2) 2024, 17–27
acta_oeconomia.sggw.pl ISSN 1644-0757 eISSN 2450-047X DOI: 10.22630/ASPE.2024.23.2.6

ORIGINAL PAPER

Received: 25.01.2024
Accepted: 29.03.2024

EFFICIENCY OF ENVIRONMENTAL PROTECTION EXPENDITURE OF THE GENERAL GOVERNMENTS IN EUROPEAN UNION MEMBER STATES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT IN WASTE MANAGEMENT

Magdalena Jarczok-Guzy✉, Jan Kaczmarzyk, Edyta Sygut

University of Economics in Katowice, Poland

ABSTRACT

Aim: Pursuing sustainable development justifies incurring expenditure in the field of environmental protection because the state's active fiscal policy is an essential determinant of achieving sustainable development goals. The distribution of public funds should depend on the efficiency of their use. The purpose of the research procedure is (1) to analyze the structure of environmental protection expenditure of the general government in the European Union and the individual member states; (2) to assess the efficiency of environmental protection expenditure of the general government in the implementation of sustainable development goals in waste management. **Methods:** The study uses linear regression with regression confidence bounds. The indicator chosen to assess the efficiency of expenditure was the Recycling rate of municipal waste (SDG_11_60). **Results:** The structure of environmental protection expenditure of the general government in most member states in 2012–2021 was stable, which may result from the adopted national environmental policies or internal conditions of a given country. Waste management expenditure dominates the structure of environmental protection expenditure of the general government in many countries. The analysis of the efficiency of environmental protection expenditure of the general government in waste management confirmed its efficiency in a significant number of states. **Conclusions:** The research procedure indicated that positive relations between general spending on the environment and achieving sustainable goals can be confirmed. Unfortunately, there is a problem with data consistency of various indicators measuring sustainable goals. Therefore, extending such research to a multiple factor case, for example, can be difficult.

Key words: environmental protection expenditure, sustainable development indicators, sustainable development goals, efficiency, waste management

JEL codes: H41, H50, H72, F64

INTRODUCTION

Environmental deterioration and resource unsustainability are major global concerns as they pose serious threats to ecosystems, human health, and the economy [Ortega-Gil et al. 2022]. Ensuring sustainable development is the basis for the vision formulated in strategic documents and action plans at the national and supranational levels. The policy of the European Union is based on the desire to create conditions for running a modern, resource-saving, and competitive economy, ensuring a high quality of life for current and future generations. In the last five years,

Magdalena Jarczok-Guzy https://orcid.org/0000-0001-9373-1264; Jan Kaczmarzyk https://orcid.org/0000-0002-4139-8858; Edyta Sygut https://orcid.org/0000-0002-3644-0505
✉ magdalena.guzy@ue.katowice.pl

the European Commission has issued several essential documents, adopting many commendable policies with the primary aim of preventing waste generation while addressing the problem at its root and maximizing the recovery of raw materials and energy from waste [Jarczok-Guzy 2023]. One of these documents pertains to the obligation of selective waste collection, allowing for the recycling of waste such as paper, cardboard, glass, metal, plastic, and clothes [Kukuła 2016]. Sustainable development is not possible without appropriate financial adjustments. Striving for sustainable development justifies incurring expenditure in environmental protection because the active fiscal policy of the state is essential. The essential concept of sustainable development integrates three components: social development and economic development, and considering environmental aspects [Sobczak 2021]. The challenge of sustainable development is the pursuit of satisfying needs without exerting excessive influence on the natural environment.

Environmental protection expenditures play a significant role in shaping an effective environmental policy and achieving sustainable development goals. Therefore, these expenditures should be carefully monitored, and their effectiveness should be examined from the perspective of the sustainable development goals. Our study contributes to the existing literature by heightening the existing knowledge on environmental expenditures. While there are many studies on environmental expenditures, studies on their effectiveness in terms of achieving sustainable development goals are rather hard to find. The purpose of the research procedure is (1) to analyze the structure of environmental protection expenditure of the general government in the European Union and the individual member states, and (2) to assess the efficiency of environmental protection expenditure of the general government in the implementation of sustainable development goals in waste management. The research hypothesis is that the higher the government's environmental protection expenditures, the more efficient waste management should be.

Sustainable development – goals and measures

The 2030 Agenda for Sustainable Development, initiated by the United Nations in 2015, contains 17 Sustainable Development Goals (SDGs), which aim to solve the most urgent problems related to social, environmental, and economic development in the world. For the global implementation of the 2030 Agenda to take place, it is necessary to integrate the SDGs with the policies and practices of all countries at all levels of government [Mortimer et al. 2023]. The SDGs are based on the Millennium Development Goals established in 2000 and address global challenges in health, education, equity and social justice, economic security, and environmental issues. The SDGs include not only 17 general goals but also 169 specific objectives. All countries' economic and social development goals must have common general characteristics. They must result from a consensus on the basic concept of sustainable development and a broad strategic framework for their achievement [Ashford and Hall 2011]. In particular, knowledge about the benefits and pollution damage, or the costs and benefits of pollution reduction, is required [Perman et al. 2003].

Implementation of sustainable development requires measurements, without which it is hard to discuss effective and efficient management [Szajczyk 2021, Broniewicz et al. 2022]. Adequate information and indicators are needed to monitor progress and evaluate results, and those indicators should meet the following criteria [Bąk and Cheba 2020]:

- policy relevance: the indicator must address issues that are of public interest and relevant to policy-making;
- analytical validity: ensuring that the indicator is based on the best scientific knowledge available;
- measurability: indicators must allow meaningful comparisons over time as well as over space (in the countries or regions under study);
- communication usefulness: delivering understandable, easily interpreted signals to the target audience.

The implementation of sustainable development goals by individual countries is verified at three levels. Firstly, the United Nations Statistical Commission has developed a set of global indicators to assess progress. At the regional level, within the European Union, Eurostat monitors progress in achieving the SDGs in the member states using a set of 100 indicators. Additionally, the governments of UN member states utilize their own national measures for SDG implementation [Krasodomska et al. 2022].

Public environmental protection expenditure

The environment is considered to be everything that creates the natural conditions necessary for the existence of organisms. Therefore, an ecologically sound environment is also a condition for human health and well-being, as well as the safe and healthy existence of all organisms [Mihaliková et al. 2022]. Stiglitz identified the natural environment as one of the five examples of global public goods, alongside international economic stability, national security, international humanitarian aid, and knowledge [Stiglitz 1995]. Global public goods have an intergenerational and transnational character, therefore requiring coordinated action at the international level. The intergenerational nature of global public goods is highlighted by Sandler [Sandler 2009]. This means that decisions, or the lack thereof, have implications for future generations.

Global public goods should be analyzed in contrast to global public bads [Kopiński and Wróblewski 2020]. If we consider the natural environment to be a global public good [Pearce and Palmer 2005], environmental pollution should be viewed as a global public bad (i.e., an undesirable state requiring action to limit the adverse effects). State intervention is an effective method of eliminating harmful phenomena caused by environmental pollution [Krasodomska et al. 2022]. Providing global public goods, also understood as corrective actions related to global public bads, requires the involvement of financial resources. As a rule, national public goods are financed from national public funds. On the other hand, the supranational character of global goods determines the necessity of actions and regulations at the international level. As a consequence, the assessment of public spending on environmental protection becomes particularly important [Mandalová 2012]. The implementation of conceptual assumptions depends to a large extent on the quality of the legal environment. Legal standards that regulate activities in environmental protection require consistency at the international level, including European Union law and national law. The coherence of the law should address issues related to the environmental goals being pursued, as well as the sources and level of funding for activities associated with these goals.

Expenditure resulting from the implementation of environmental activities by the public sector is referred to as environmental public expenditure. According to Bishop, public expenditure on environmental protection can be defined as the expenditure incurred by the relevant public authorities responsible for environmental protection [Bishop 2013]. It is possible to analyze the spending of public funds for environmental protection purposes using the EU methodology of public expenditure classification. Additionally, having uniform rules for classifying public expenditure allows for international comparisons. This is particularly important in the context of environmental protection, which is considered a global public good.

Public spending is a tool for influencing various entities' economic behavior in terms of their approach to environmental protection. As a consequence, expenditures on environmental protection are a crucial factor in shaping an effective environmental policy. Therefore, it is necessary to know the level of expenditure and the activities for which they were allocated, and to monitor and assess the effects of the actions taken. Hence, the question arises about the efficiency of environmental protection expenditures in implementing sustainable development goals.

MATERIALS AND METHODS

The subject of the research is the analysis of environmental protection expenditure of the general government by function (COFOG division 05) in the European Union from 2012 to 2021, in order to implement sustainable development goals. The research was conducted in two stages.

The framework of the first stage was to initially examine the structure of environmental protection expenditure of the general government by function (COFOG) in the European Union (EU) and individual member states (MS). The data used in the research procedure comes from the Eurostat database. The methodological framework is the European System of Accounts (ESA 2010); [Dz.UE L 174 z 26.06.2013]. Environmental protection expenditure of the general government by function (COFOG division 05); (GF05) includes [Manual on sources… 2019]: Waste

Table 1. Selected measure of sustainable development in waste management

Environmental protection expenditure	No	SD IndicatorCode	Measure	Indicator
waste management	Y1	SDG_11_60	% of total waste generated	Recycling rate of municipal waste

Source: own study.

management (GF0501); (X1), wastewater management (GF0502), pollution abatement (GF0503), protection of biodiversity and landscape (GF0504), R&D environmental protection (GF0505), and environmental protection N.E.C. (GF0506).

The second stage of the research procedure assessed the efficiency of environmental protection expenditure of the general government in the area of interdependence of spending on waste management (GF0501) with a selected measure of sustainable development. For this purpose, linear regression with regression confidence bounds was used after an initial graphical analysis of scatter plots and identification of unequivocal linear patterns. The linear regression has been chosen because the paper tries to analyze the situation in every state and the EU separately. The confidence bounds help to understand the relation between the expenditure under examination and the chosen indicator. Additionally, a regression slope and an intercept have been provided together with the determination coefficient for each state and the EU. The confidence interval has also been calculated for regression slopes (95% confidence level) to indicate the range of possible error. The *p*-values have been calculated to decide whether the relation is statistically significant or not in the case of a particular state. The indicator chosen to assess the efficiency of expenditure was the recycling rate of municipal waste (SDG_11_60); (Table 1).

In the case of SDG_11_60 (Y1), the sample consisted of 10 yearly values, which is a relatively small sample size. The research procedure aims to: (1) analyze the structure of environmental protection expenditure by the general government in the European Union and its individual member states; (2) assess the efficiency of environmental protection expenditure by the general government in implementing sustainable development goals, using the relationship between expenditure on waste management and selected measures of sustainable development as an example.

RESULTS

The structure of environmental protection expenditure of the general government in most member states in 2012–2021 was stable. This stability may have resulted from the adopted national environmental policies or the internal conditions of a given country. This stability allowed for the summing up of environmental protection expenditure of the general government in the period 2012–2021, in order to determine the ranking of countries according to the dominant outlay (Table 2).

The structure of environmental protection expenditure of the general government among the EU-27 member states is diversified. Taking into account the largest share of the total multi-annual spending in the structure, it is possible to indicate five groups of countries with dominating outlay: waste management, wastewater management, pollution abatement, protection of biodiversity and landscape, environmental protection N.E.C. (Table 2).

The largest group of countries (15 countries[2]) is where the greatest share of the structure is spent on waste management. In this group of countries, the share of expenditure on waste management varied significantly. The percentage of waste management expenditure

[2] Given the incomplete data for Bulgaria, this country was not analyzed. Just like Portugal, the residual data for these countries distort the overall picture.

Table 2. Ranking of Member States by dominant outlay in the structure [%] of environmental protection expenditure of general government (multi-annual spending for 2012–2021)

Expenditure	GF0501	GF0502	GF0503	GF0504	GF0505	GF0506
Independent variable	X1					
Country	Waste management	Wastewater management	Pollution abatement	Protection of biodiversity and landscape	R&D environmental protection	Environmental protection n.e.c.
Bulgaria*	**82.7**	3.9	0.0	0.9	0.0	12.5
Cyprus	**79.1**	12.1	6.7	2.1	0.0	0.0
Italy	**65.6**	2.4	6.2	14.3	8.6	2.9
Spain	**61.1**	14.7	3.5	10.3	4.1	6.4
Latvia	**59.3**	6.8	16.9	4.2	0.7	12.0
Malta	**51.1**	20.3	4.9	17.9	0.0	5.8
France	**50.9**	20.8	8.9	8.3	3.1	8.1
Slovakia	**49.9**	11.4	7.7	8.1	2.9	20.0
Greece	**48.5**	6.7	44.0	0.2	0.0	0.6
EU27	**44.0**	18.8	15.5	9.8	4.5	7.4
Lithuania	**46.2**	8.4	16.2	8.0	0.3	21.0
Romania	**45.5**	19.5	32.7	0.1	0.0	2.1
Hungary	**42.9**	33.1	8.3	7.5	0.4	7.8
Netherlands	**41.7**	29.7	17.1	8.4	1.5	1.5
Portugal*	**36.8**	20.6	9.4	14.1	10.1	9.1
Estonia	**31.6**	11.7	17.3	18.2	11.9	9.3
Czechia	**31.5**	31.3	4.4	25.6	2.4	4.7
Germany	**29.4**	22.8	25.1	8.6	6.9	7.2
Ireland	3.9	**60.1**	6.2	22.7	1.5	5.6
Slovenia	11.7	**45.9**	17.2	9.5	7.0	8.6
Luxem-bourg	21.5	**45.4**	16.5	11.8	0.2	4.6
Poland	19.6	**38.6**	11.8	4.5	5.0	20.5
Sweden	26.4	**38.4**	2.0	8.1	2.2	22.9
Belgium	29.4	6.6	**48.5**	4.3	1.2	10.0
Austria	12.0	24.9	**39.9**	5.0	5.7	12.4
Finland	12.0	0.0	**32.1**	18.5	14.8	22.6
Denmark	8.3	2.5	11.0	**45.5**	5.9	26.9
Croatia	18.2	16.7	3.2	14.9	1.2	**45.8**

*Incomplete data

Source: own study.

Table 3. Linear relationship between GF0501 expenditure and SDG_11_60 measure in the Member States in 2012-2021 (yearly interval, 10 samples)

Region / Country	% of GF05	b1	b0	R2	df	s(b1)	b1 - CI	b1 + CI	F	p	Y1 change
Netherlands	41.73%	0.0075	20.9013	95.9%	8	0.0005	0.0063	0.0088	188.5663	0.000001	8.4%
Luxembourg	21.47%	0.1555	33.0216	91.7%	8	0.0165	0.1175	0.1936	88.8818	0.000013	7.9%
France	50.86%	0.0025	11.5024	91.7%	8	0.0003	0.0019	0.0031	87.9402	0.000014	7.4%
EU27	43.97%	0.0007	13.1387	88.3%	8	0.0001	0.0005	0.0009	60.2192	0.000054	8.7%
Croatia	18.15%	0.0761	15.8345	80.3%	8	0.0133	0.0454	0.1067	32.7056	0.000445	16.7%
Czechia	31.48%	0.0622	-3.5532	72.5%	8	0.0135	0.0310	0.0934	21.1344	0.001762	20.1%
Germany	29.37%	0.0047	41.5151	71.8%	8	0.0010	0.0023	0.0071	20.3810	0.001964	5.9%
Spain	61.12%	0.0043	7.4658	63.6%	8	0.0011	0.0016	0.0069	13.9646	0.005731	6.9%
Latvia	59.32%	0.5236	-20.5893	56.4%	8	0.1627	0.1484	0.8987	10.3570	0.012272	29.5%
Poland	19.64%	0.0467	7.3834	51.5%	8	0.0160	0.0098	0.0836	8.4974	0.019439	28.3%
Romania	45.49%	-0.0054	16.0068	36.8%	8	0.0025	-0.0112	0.0004	4.6512	0.063118	-3.5%
Estonia	31.61%	0.1400	19.8748	33.3%	8	0.0701	-0.0217	0.3018	3.9873	0.080915	11.2%
Hungary	42.92%	0.0124	27.3051	30.2%	8	0.0067	-0.0030	0.0278	3.4610	0.099871	9.4%
Sweden	26.37%	-0.0531	77.2697	28.8%	8	0.0295	-0.1211	0.0149	3.2417	0.109476	-7.4%
Malta	51.08%	-0.0407	14.9037	27.3%	8	0.0235	-0.0950	0.0135	2.9979	0.121612	-1.2%
Lithuania	46.19%	0.1425	24.6045	11.8%	8	0.1375	-0.1745	0.4594	1.0745	0.330249	20.8%
Slovenia	11.70%	-0.1310	56.2255	7.4%	8	0.1643	-0.5099	0.2479	0.6353	0.448423	17.9%
Denmark	8.30%	0.0438	41.2034	5.4%	8	0.0648	-0.1056	0.1933	0.4574	0.517895	-8.2%
Portugal	36.78%	-0.0049	30.9561	2.9%	8	0.0102	-0.0284	0.0185	0.2352	0.640687	4.4%
Belgium	29.44%	-0.0006	54.5679	2.3%	8	0.0014	-0.0040	0.0027	0.1897	0.674642	-0.1%
Finland	11.96%	0.0728	34.2682	1.9%	8	0.1826	-0.3483	0.4939	0.1589	0.700609	3.8%
Slovakia	49.89%	0.0308	16.0987	0.7%	8	0.1300	-0.2690	0.3306	0.0561	0.818654	35.5%
Cyprus	79.08%	-0.0123	16.0859	0.4%	8	0.0691	-0.1716	0.1470	0.0319	0.862719	2.8%

Source: own study.

ranged from 29.4% in Germany to 79.1% in Cyprus. Additionally, five countries had the largest proportion of expenditure allocated to wastewater management. Among these countries, Ireland spent the most (60.1%), while Sweden spent the least (38.4%). Belgium, Austria, and Finland had the highest pollution abatement spending. On the other hand, Denmark and Croatia allocated the most significant proportion of their expenditure to biodiversity and landscape protection and environmental protection N.E.C., respectively. In the second stage of the research procedure (Table 3), the efficiency of environmental protection expenditure by the general government was assessed in relation to spending on waste management (GF0501) and a measure of sustainable development (SDG_11_60). Due to incomplete time series, Bulgaria, Italy, Greece, Ireland, and Austria were excluded from the analysis.

Countries in which the relationship between GF0501 expenditure and the SDG_11_60 measure is positive, with a 95% confidence level, are the Netherlands, Luxembourg, France, EU27, Croatia, Czechia, Germany, Spain, Latvia, and Poland. It should be noted that in these countries, the GF0501 expenditure acts as a stimulant for the SDG_11_60 measure, as expected. The p-value for these countries was lower than the 5% significance level adopted in the research procedure, indicating that the positive slope value in these countries is statistically significant. At the same time, these indicated countries are the ones in which changes in GF0501 expenditure explain more than 50% of the changes in the SDG_11_60 measure. This suggests that the efficiency of GF0501 expenditure in implementing the concept of sustainable development is high. The coefficient of determination was 95.93% in the Netherlands, 91.74% in Luxembourg, 91.66% in France, 88.27% in EU27, 80.35% in Croatia, 72.54% in Czechia, 71.81% in Germany, 63.58% in Spain, 56.42% in Latvia,

and 51.51% in Poland. Among these countries, Spain has a relatively high share of GF0501 expenditure in total GF05 expenditure, while Croatia has a relatively low share. This allows us to conclude that relatively low spending can be effectively allocated. On average, during the period under consideration, the share of GF0501 expenditure in total GF05 expenditure was as follows: Spain (61.12%), Latvia (59.32%), France (50.86%), EU27 (43.97%), the Netherlands (41.73%), Czechia (31.48%), Germany (29.37%), Luxembourg (21.47%), Poland (19.64%), and Croatia (18.15%). For the entire group, this share averaged to 37.71%. Interestingly, the coefficient of determination in this group exceeded 90%, as illustrated for the Netherlands (Fig. 1), Luxembourg, and France. The efficiency of GF0501 expenditure in implementing the concept of sustainable development, as determined by the SDG_11_60 measure, can be considered exceptionally high. During the analyzed period, an increase in the SDG_11_60 measure was observed in all countries with a clearly positive relationship: Latvia (by 29.5%), Poland (by 28.3%), Czechia (by 20.1%), Croatia (by 16.7%), EU27 (by 8.7%), the Netherlands (by 8.4%), Luxembourg (by 7.9%), France (by 7.4%), Spain (by 6.9%), and Germany (by 5.9%). The countries that joined the EU after 2004 showed a higher level of improvement in the SDG_11_60 measure compared to the EU27. The relatively low improvement of the SDG_11_60 measure in countries with exceptionally high determination coefficients should not be seen as negative, as these countries exhibited significantly higher determination levels at the beginning of the analyzed period.

In the remaining 13 countries, the linear regression slope is positive in six countries and negative in seven countries. It cannot be confirmed with 95% confidence whether it is positive or negative. The *p*-value for the remaining 13 countries was higher than the assumed 5% significance level. Therefore, the slope value in these countries should not be considered statistically significant. Consequently, it is impossible to unequivocally assess the efficiency of GF0501 expenditure in terms of improving the SDG_11_60 measure. Nevertheless, it is interesting to note that there are countries with a negative linear regression coefficient. This suggests that the expenditure does not contribute to improving the measure characterizing sustainable development. Negative linear regression coefficients were found for Romania, Sweden, Malta, Slovenia, Portugal, Belgium, and Cyprus. The share of GF0501 expenditure in total GF05 expenditure in the period under consideration was, on average, as follows in these countries: Cyprus (79.08%), Malta (51.08%), Romania (45.49%), Portugal (36.78%), Belgium

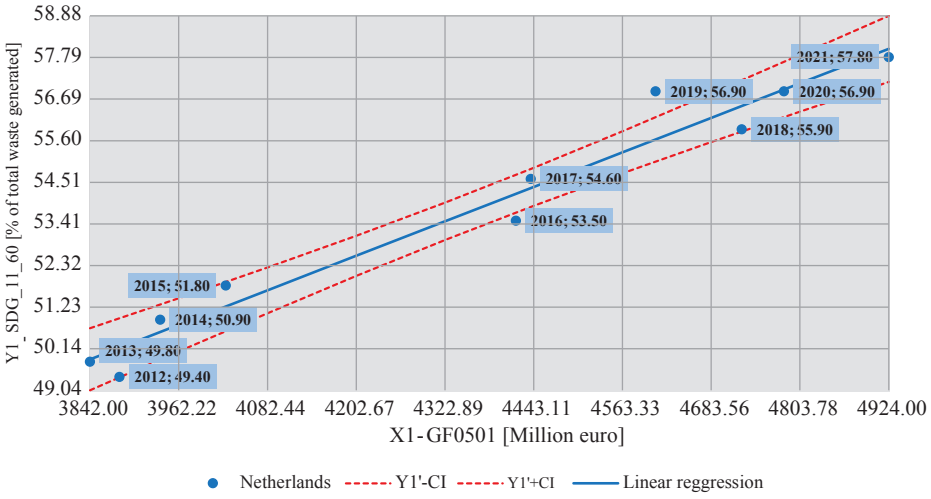


Fig. 1. Linear relationship between GF0501 expenditure and SDG_11_60 measure – Netherlands in 2012–2021
Source: own study.

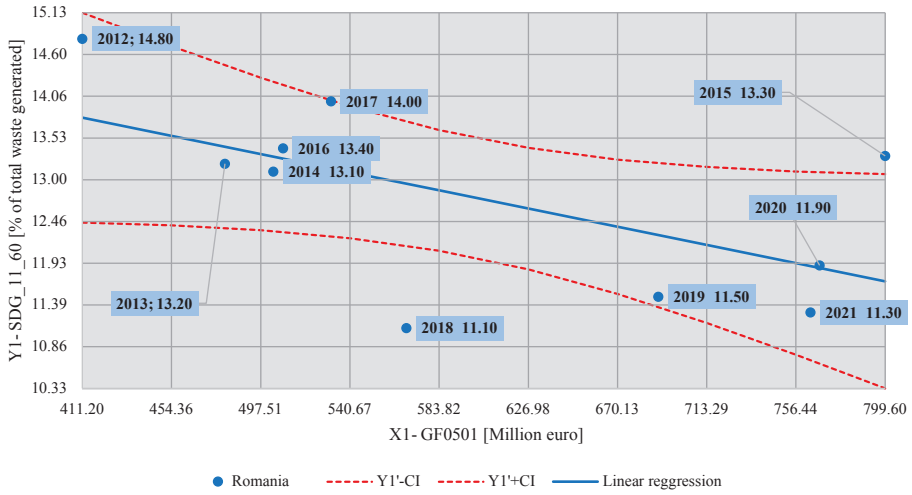


Fig. 2. Linear relationship between GF0501 expenditure and SDG_11_60 measure – Romania in 2012–2021
Source: own study.

(29.44%), Sweden (26.37%), and Slovenia (11.70%). It should be noted that these percentages vary greatly. Moreover, among the countries with a negative coefficient, some have a very high share of GF0501 expenditure in the overall spending structure. Within this group, special attention should be given to Romania, as the *p*-value of 0.063118 is close to the significance level adopted in the research procedure (Fig. 2).

Although the observed relationship is not statistically significant, the graphical assessment indicates that the measure has deteriorated. Therefore, it can be presumed that the GF0501 expenditure is ineffective. With nearly double the expenditure of GF0501, there is a noticeable decline in the SDG_11_60 measure.

DISCUSSION

Previous studies have included an analysis of the amount of expenditure on environmental protection [Bobáková and Mihaliková 2019, Dziawgo 2022] and the structure of expenditure on environmental protection based on spending purposes [Bobáková and Mihaliková 2019, Sobczak 2021, Dziawgo 2022]. However, their geographical and temporal scope was fragmented. This article covers all European Union countries over a relatively long period (2012–2021), which allows for formulating conclusions regarding the policy of spending public funds for environmental purposes in individual member states.

The concept of sustainable development and the financing of environmental protection are widely discussed issues in the literature. However, the efficiency of environmental protection activities, including waste management, has remained a niche topic. Monitoring progress is a necessary step in implementing the concept of sustainable development correctly. Sustainable development often has a non-financial dimension in social or economic policy, which makes progress monitoring challenging. As a result, numerous studies have focused on the selection of indicators in sustainable development management [Balas and Molenda 2016, Szyja and Michalak 2023].

Tasks in this area require both time and financial resources, which raises the question of their efficiency. Efficiency is understood in two ways in the literature. First, efficiency, as the efficacy of action, means that its result aligns with the intended goal. Second, efficiency expresses the relationship between the achieved goal (result) and the expenditure incurred to achieve it [Penc 1997]. Previous studies indicate that an increase in expenditure on environmental protection does not necessarily lead to a proportional increase in efficiency [Barrell et al. 2021, Mihaliková et al. 2022]. This study is part of the research on the efficiency of expenditure

on environmental protection [Ercolano and Romano 2018, Barrell et al. 2021, Sobczak 2021]. The research conducted by the authors builds upon previous studies on the efficiency of expenditure on environmental protection in waste management, specifically in the context of sustainable development goals [Mihaliková et al. 2022]. The study by Mihaliková et al. [2022] utilized data for the entire European Union, treating both the EU as a whole and individual member states as subjects of research. Their research confirmed the effectiveness of funds spent on waste management in the European Union by examining the relationship between public spending and the recycling rate of municipal waste, as well as energy recovery of communal waste [Mihaliková et al. 2022]. In this research procedure, the recycling rate of municipal waste was used as a common measure. The efficiency of spending funds was confirmed for both the European Union and individual member states. The use of the recycling rate of municipal waste as a measure confirmed the efficiency of waste management expenditure for the entire European Union, although not for all member states.

CONCLUSIONS

The concept of sustainable development and broadly understood environmental protection is a priority of European Union policy. Economic incentives, including fiscal incentives, are important factors in achieving sustainable development goals. The need to spend on environmental protection is constantly increasing and is mainly driven by the need to balance economic development with environmental care. When assessing expenditure on environmental protection, European Union countries should consider the expected environmental effects. Firstly, waste management expenditure dominates the structure of environmental protection expenditure for most countries. Secondly, an analysis of the efficiency of environmental protection expenditure in waste management confirms its efficiency, specifically in terms of the recycling rate of municipal waste. The efficiency of expenditure was verified using the SDG_11_60 measure in the Netherlands, Luxembourg, France, EU27, Croatia, Czechia, Germany, Spain, Latvia, and Poland. The hypothesis that higher government expenditure on environmental protection leads to more efficient waste management has been confirmed for these countries. However, in other countries, it is not possible to unequivocally assess the efficiency of GF0501 expenditure in improving SDG_11_60, and the hypothesis cannot be confirmed. It is worth noting that Romania deserves special attention as a negative relationship was observed, indicating that an increase in GF0501 expenditure would decrease the value of the measures, which is contrary to logic. Thirdly, conducting research on the efficiency of environmental protection expenditure is essential, not only in the field of waste management but also in other areas. However, the quality of the measures poses an obstacle to such studies. Analyzing the efficiency of spending public funds in a sustainable context requires complete and consistent data at annual intervals. The limitation lies in the availability and number of samples. Some SDGs are collected yearly while others are collected every two years, and this inconsistency hinders a deeper analysis of general spending efficiency. Fourthly, an alternative solution would be to use a method that allows for simultaneous consideration of multiple measures in assessing the efficiency of environmental protection expenditure of general government.

REFERENCES

Ashford, N.A., Hall R.P. (2011). Technology, Globalization and Sustainable Development. Transforming the Industrial State. Yale University Press, London.

Barrell, A., Dobrzanski, P., Bobowski, S., Siuda, K., Chmielowiec, S. (2021). Efficiency of Environmental Protection Expenditures in EU Countries. Energies, 14, 8443. https://doi.org/10.3390/en14248443

Balas, A., Molenda, A. (2016). Koncepcja doboru wskaźników zrównoważonego rozwoju Polski oraz narzędzie ich udostępniania i prezentacji (The concept of selecting instruments for Polish development and the tools for their sharing and presentation). Optimum. Studia Ekonomiczne, 2(80), 97–114. https://doi.org/10.15290/ose.2016.02.80.08

Bąk, I., Cheba, K. (2020). Zielona gospodarka jako narzędzie zrównoważonego rozwoju (Green economy as a tool for sustainable development). CeDeWu, Warszawa.

Bishop, B.H. (2013). Context and Place Effects in Environmental Public Opinion. Duke University Library, Durham, NC, USA. Retrieved from https://dukespace.lib.duke.edu/dspace/handle/10161/7273 [accessed: 26.05.2023].

Bobáková, V., Mihaliková, E. (2019). Public Expenditure for the Environmental Protection in Slovakia. TEM Journal, 8(3), 921–927.

Broniewicz, E., Bukowska, J., Godlewska, J., Lulewicz-Sas, A., Sidorczuk-Pietraszko, E. (2022). Climate change adaptation in ex-ante assessment of legal acts – a proposal of indicators for Poland. Economics and Environment, 82(3), 52–73.

Dziawgo, E. (2022). Analysis of changes in waste generation and management in Poland against the background of EU waste management objectives. Research Papers of Wrocław University of Economics, 66(4), 41–56.

Ercolano, S., Romano, O. (2018). Spending for the Environment: General Government Expenditure Trends in Europe. Social Indicators Research, 138, 1145–1169.

Jarczok-Guzy, M. (2023). Communes' Expenditure on Municipal Waste Management in Terms of Sustainable Development. Annales Universitatis Mariae Curie-Skłodowska, sectio H – Oeconomia, 57(4), 85–101. https://doi.org/10.17951/h.2023.57.4.85-101

Kopiński, D., Wróblewski, M. (2020). Globalne dobra publiczne a organizacje międzynarodowe (Global public goods and international organizations). Difin, Warszawa.

Krasodomska, J., Zarzycka, E., Dobija, D. (2022). Czynniki determinujące raportowanie przez przedsiębiorstwa informacji o działaniach na rzecz realizacji Celów Zrównoważonego Rozwoju (Factors determining the reporting by enterprises of information on activities to implement the Sustainable Development Goals). Zeszyty Teoretyczne Rachunkowości, 46(3), 99−118.

Kukuła, K. (2016). Municipal waste management in Poland in the light of multi-dimensional comparative analysis, Acta Scientiarum Polonorum. Oeconomia, 15(4), 93–103.

Mandalová, K. (2012). An assessment of the expenditure to be spent for environmental protection. Retrieved from: http://www.slpk.sk/eldo/2012/zborniky/025-12/13.pdf [accessed: 23.06.2023].

Manual on sources and methods for the compilation of COFOG statistics. Classification of the functions of government (COFOG). Eurostat, 2019. Retrieved from https://ec.europa.eu/eurostat/documents/3859598/10142242/KS-GQ-19-010-EN-N.pdf [accessed: 27.04.2023].

Mihaliková, E., Taušová, M., Culková, K. (2022). Public expenses and investment in environmental protection and its impact on waste management. Sustainability, 14, 5270. https://doi.org/10.3390/su14095270

Mortimer, A., Ahmed, I., Johnson, T., Tang, L., Alston, M. (2023). Localizing Sustainable Development Goal 13 on Climate Action to build local resilience to floods in the Hunter Valley: a literature review. Sustainability, 15, 5565. https://doi.org/10.3390/su15065565

Ortega-Gil, M., Cortés-Sierra, G., ElHichou-Ahmed, C. (2021). The Effect of Environmental Degradation, Climate Change, and the European Green Deal tools on life satisfaction. Energies, 14, 5839. https://doi.org/10.3390/en14185839

Pearce, D., Palmer, C. (2005). Public and private spending for environmental protection: a cross-country policy analysis. Fiscal Studies, 22, 403–456. https://doi.org/10.1111/j.1475-5890.2001.tb00048.x

Penc, J. (1997). Leksykon biznesu (Business lexicon). Placet, Warszawa.

Perman, R., Ma, Y., McGilvray, J., Common, M. (2003). Natural resource and environmental economics. Pearson Addison Wesley, Essex.

Sandler, T. (2009). Intergenerational public goods: transnational considerations. Scottish Journal of Politcal Economy, 56(3), 353–370. https://doi.org/10.1111/j.1467-9485.2009.00488.x

Sobczak E. (2021). Wstęp (Introduction) [In:] E. Sobczak (ed.), Zrównoważony rozwój jednostek samorządu terytorialnego oraz przyczyny spowolnienia realizacji celów strategicznych (Sustainable development of local government units and reasons for the slowdown in the implementation of strategic goals). Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 8–11.

Stiglitz, J. (1995). The theory of international public goods and the architecture of international organizations. United Nations Background Paper, 7, Department for Economic and Social Information and Policy Analysis.

Szajczyk, M. (2021). Polityka zrównoważonego rozwoju – gospodarka cyrkularna (Sustainable development policy – circular economy). Wydawnictwo Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach, Siedlce.

Szyja, P., Michalak, D. (2023). Determinants of climate security – an attempt at indicator analysis. Economics and Environment, 84(1), 8–28. https://doi.org/10.34659/eis.2023.84.1.551

Regulation (EU) No 549/2013 of the European Parliament and of the council of 21 May 2013 on the European system of national and regional accounts in the European Union (Dz.UE L 174 z 26.06.2013). Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:174:0001:0727:EN:PDF [accessed: 02.06.2023].

Jarczok-Guzy M., Kaczmarzyk J., Sygut E. (2024). Efficiency of environmental protection expenditure of general governments in Europiean Union member states in the context of sustainable development in waste management Acta Sci. Pol. Oeconomia 23 (2), 17–27, DOI: 10.22630/ASPE.2024.23.2.6

EFEKTYWNOŚĆ WYDATKÓW SEKTORA INSTYTUCJI RZĄDOWYCH I SAMORZĄDOWYCH NA OCHRONĘ ŚRODOWISKA W PAŃSTWACH UNII EUROPEJSKIEJ W KONTEKŚCIE ZRÓWNOWAŻONEGO ROZWOJU

STRESZCZENIE

Cel: Dążenie do zrównoważonego rozwoju uzasadnia ponoszenie wydatków w zakresie ochrony środowiska naturalnego, bowiem aktywna polityka fiskalna państwa jest istotną determinantą osiągania celów zrównoważonego rozwoju. Dystrybucja środków publicznych powinna zależeć od efektywności ich wykorzystania. Celem postępowania badawczego jest: (1) analiza struktury wydatków sektora instytucji rządowych i samorządowych na ochronę środowiska w Unii Europejskiej i w poszczególnych państwach członkowskich; (2) ocena efektywności wydatków sektora instytucji rządowych i samorządowych na ochronę środowiska w realizacji celów zrównoważonego rozwoju w zakresie gospodarowania odpadami. **Metody:** W badaniu wykorzystano regresję liniową z granicami ufności regresji. Do oceny skuteczności wydatków wykorzystano wskaźnik poziomu recyklingu odpadów komunalnych (SDG_11_60). **Wyniki:** Struktura wydatków publicznych na ochronę środowiska w większości krajów członkowskich w latach 2012–2021 była stabilna, co może wynikać z przyjętych krajowych polityk środowiskowych lub uwarunkowań wewnętrznych danego kraju. W największej liczbie państw w strukturze wydatków sektora instytucji rządowych i samorządowych na ochronę środowiska dominują wydatki w zakresie gospodarowania odpadami. Analiza efektywności wydatków sektora instytucji rządowych i samorządowych na ochronę środowiska w gospodarce odpadami potwierdziła ich efektywność w znacznej liczbie państw. **Podsumowanie:** Postępowanie badawcze wskazało, że można potwierdzić zależność pozytywną pomiędzy wydatkami a osiąganiem celów zrównoważonego rozwoju. Niestety, istnieje problem spójności danych dotyczących różnych wskaźników mierzących zrównoważony rozwój, przez co rozszerzenie postępowania badawczego do przypadku wielowymiarowego jest utrudnione.

Słowa kluczowe: wydatki na ochronę środowiska, mierniki zrównoważonego rozwoju, cele zrównoważonego rozwoju, efektywność, gospodarowanie odpadami

Acta Sci. Pol.
Oeconomia 23 (2) 2024, 29–40
acta_oeconomia.sggw.pl ISSN 1644-0757 eISSN 2450-047X DOI: 10.22630/ASPE.2024.23.2.7

ORIGINAL PAPER

Received: 12.02.2024
Accepted: 29.03.2024

PRO-INFLATIONARY SIGNIFICANCE OF ENERGY COMMODITY AND ELECTRICITY PRICES

Dominik Katarzyński✉, Grzegorz Przekota

Koszalin University of Technology, Poland

ABSTRACT

Aim: The main aim of this article is to evaluate the influence of electricity prices on the overall economic price level. **Methods:** The research methodology was carefully designed to encompass various analytical tools, including the graphical representation of data, basic statistical analyses, the computation of the Pearson correlation coefficient with consideration of time lags, and the application of the Granger causality test. **Results:** The outcomes of the study revealed a significant inefficiency within the market mechanism. Contrary to expectations, the anticipated correlation between electricity prices and inflation (PPI and CPI) indices was found to be statistically insignificant. However, among the examined relationships, a strong and noteworthy connection emerged between coal prices and the PPI inflation index, particularly with a distinct two-month lag in this correlation. **Conclusions:** Drawing conclusions from the analysis, it became evident that while energy commodity prices, such as coal, do not directly translate into electricity prices and subsequently influence inflation, coal prices do emerge as a significant predictor of inflation. This observation suggests a gap in the intermediate stage of the production cycle, shedding light on a pronounced market inefficiency. The significance of these findings extends beyond the narrow scope of the energy sector. They provide a broader perspective on pricing relationships in the economy, highlighting the limited impact of the market price of electricity on shaping the overall price level. This nuanced understanding constitutes a noteworthy and valuable contribution to the field of economic research, emphasizing the multifaceted dynamics that underlie pricing mechanisms in a complex economic system.

Key words: energy, electricity, coal, CPI, PPI
JEL codes: E300, E310, E710

INTRODUCTION

The issue of price formation in the economy

The issue of how energy commodity and electricity prices affect overall prices in the economy has become increasingly significant since the beginning of the 2020s, particularly in the field of economic research [Ezeaku et al. 2021]. This situation has been influenced by a variety of factors – including not only recent global events, but also a wide range of decisions made at all levels of public administration in the previous decades [Schlacke et al. 2022].

The matter of price formation in the economy should not be exclusively linked to fluctuations in electricity prices and energy commodities [De Gregorio 2012]. However, due to their widespread use in the modern economy, it would be reasonable to assume that increases in the prices of these production factors can have a significant impact on the final prices

Dominik Katarzyński https://orcid.org/0000-0001-6036-4066; Grzegorz Przekota https://orcid.org/0000-0002-9173-2658
✉ dominik.katarzynski@tu.koszalin.pl

of products and services in the economy. It is worth noting, however, that beyond the prices of energy in a broad sense, numerous factors stemming from both internal and external conditions of a given economy can significantly influence prices in the economy [Nagy et. al. 2018].

Researchers indicate that one of the key factors influencing the level of inflation is the functioning of the classical market equilibrium model [Raghutla 2020], where the coexistence of demand and supply in a particular market contributes to determining the so-called "equilibrium price and quantity". Any changes in demand and supply, especially phenomena related to shortages and surpluses, can significantly impact the final determination of the price [Loxton et al. 2020].

Presently, it is generally acknowledged in the majority of countries worldwide that government authorities should intervene in the free market to some extent [Majone 2019]. This sentiment is echoed in Poland, where the constitution (Article 20) establishes the economic system in the country as the so-called "social market economy" [Constitution of the Republic of Poland 1997]. This gives public administration authorities the highest mandate for economic intervention. However, state intervention, particularly in terms of setting minimum and maximum prices or altering tax rates on specific products and services, can have implications for shaping prices in the economy [Seremak-Bulge et al. 2006]. When implementing minimum prices, the state often aims to protect producers, while maximum prices are introduced to safeguard consumers. Similarly, the regulation of tax rates on products and services, including excise taxes, can also significantly impact overall price levels in the economy [Ferrara et al. 2021].

In Poland, fixed electricity prices for households and some businesses are a relatively common phenomenon [Gabryś 2020]. However, this is not the norm globally, as exemplified by recent fluctuations in electricity prices in Texas [Brown et al. 2022], which led to a sharp increase in costs for consumers.

State intervention in the free market, often expressed in strategic sectors of the economy, is not the sole determinant of prices. Scientific discourse also highlights entrepreneurial initiative as a significant factor contributing to inflation [Weber and Wasner 2023]. Given their nature, companies primarily seek to maximize profits or enhance their value for shareholders from a financial standpoint [Widarti and Pramajaya 2018]. These fundamental objectives of companies make them inclined to increase the prices of their offered products and services as long as it results in tangible benefits for the company. Consequently, businesses meticulously utilize any opportunities arising from the conditions of a given market, thereby contributing to the final price level in that market or on a broader scale within the entire economy [Loxton et al. 2020]. Cognitive factors, specifically psychological aspects, are also considered pivotal in the context of price formation in the economy. History has witnessed numerous instances where individuals, influenced by external factors often causing panic, made seemingly irrational decisions by purchasing specific products in large quantities, thereby significantly increasing demand and subsequently, prices. In recent years, events such as the COVID-19 pandemic and the armed conflict in Ukraine have contributed to such behaviors [Caldara et al. 2022]. Amid widespread panic, prices of essential products such as sugar, masks, and disinfectants during the pandemic, or fuels, coal, and gas during the conflict in Ukraine, experienced substantial fluctuations, often witnessing significant price hikes in a very short period. This, particularly in the case of energy commodities, could imply a chain reaction on inflation throughout the entire economy [Guenette et al. 2022].

The issue of energy in the economy

The energy sector in Poland, as well as in many other countries worldwide, is perceived as strategic. Consequently, public administration authorities intervene in this branch of the economy in a particular manner [Szkutnik and Sobota 2010]. State intervention in the national energy sector can take direct forms such as implementing maximum prices, regulating tax rates, imposing energy consumption restrictions, price rigidities, etc. [Sikorska 2021]. It can also be indirect through the implementation of national and European policies concerning the future directions of the sector's development [EU Directives EU/2019/944; EU/2019/943].

As of 2023, the Polish energy market is partially liberalized, thanks to the simultaneous operation of a rigid, "frozen" electricity price for households and

certain businesses [Gabryś 2020]. The rates are determined based on consumption thresholds. Meanwhile, liquid prices, which are expressed through market principles, are facilitated by the Towarowa Giełda Energii – TGE [Grudziński et al. 2023].

Furthermore, the energy market includes not just electricity, but also energy commodities like coal, gas, oil, and gasoline. The prices of these commodities are determined by the free market and are also traded on global exchanges. They are often vulnerable to speculative activities [Conrad 2023]. The state, at most, intervenes to safeguard consumers, not through price policies but by implementing subsidies. This was observed in 2022 when subsidies were introduced for coal, leading to increased demand and subsequent price growth [Prokopowicz 2023].

The market for liquid fuels in Poland is also characterized by state intervention, albeit indirectly through the monopoly of state-owned capital companies, in which the state holds a majority stake [Leszkiewicz-Kędzior 2014]. As a result, political decisions may have an impact on the final retail and wholesale prices of liquid fuels and subsequently influence the overall inflation rate in the economy.

Energy prices can also be influenced by policies and development strategies in the energy sector. Strategic documents such as 'Polska Polityka Energetyczna do 2040' or the EU's 'Fit for 55' package could potentially impact future changes in energy prices. Both strategic documents outline a comprehensive energy transformation plan, which includes the diversification of energy generation, investments in nuclear energy, modernization of transmission networks, and efforts to reduce pollution and greenhouse gas emissions [Zarębski and Katarzyński 2023]. This transformation will require significant investment, and the financing needs may be partially reflected in energy prices in the future.

The specific characteristics of electricity in Poland

Electricity plays a fundamental role in the lives of every individual. Nowadays, conducting regular daily life and economic activities without it seems practically impossible. Therefore, it seems rational to assume that its prices can significantly impact the level of inflation in the economy [Adi et al. 2022].

It is worth noting that electricity can be generated in many ways, ranging from less to more environmentally friendly methods. However, in the case of Poland, the vast majority of energy is produced using hard coal and lignite [PSE 2023], constituting over 75% of the energy structure (Fig. 1).

In light of the presented structure (Fig. 1), it can be observed that electricity prices in Poland should be relatively strongly correlated with the market price of coal. This, in turn, may have implications for the final prices of products and services due to the widespread use of electricity in the economy.

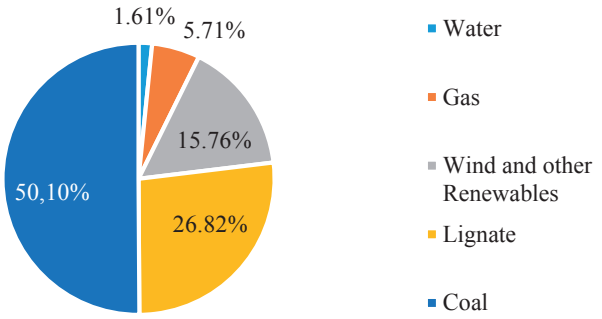


Fig. 1. Structure of electricity generation in Poland in 2022
Source: own study based on the report of Report of PSE for 2022 [2023].

The main goal of this study is to verify the impact of electricity prices on the overall price level in the economy. Achieving this objective is based on exploring the interrelationships between global coal prices, the market price of electricity in Poland, and the inflation levels measured by the PPI (Producer Price Index) and CPI (Consumer Price Index). This has led to the formulation of the following research questions:

1. How do changes in energy commodity prices affect the inflation level in Poland?
2. How does the change in electricity prices contribute to changes in the inflation level in Poland?

Due to the significance of coal for Poland's energy sector and the widespread use of electricity in the economy, a hypothesis has been adopted assuming a connection between coal prices, electricity prices, and the level of inflation in the economy.

MATERIALS AND METHODS

The research conducted in this study is based on a literature review regarding the pro-inflationary impact of energy, an examination of key documents and policies related to energy development, and a statistical analysis of a dataset spanning from 2021 to 2023. The dataset includes:

- monthly PPI and CPI indicators;
- the average monthly energy prices according to the TGE in PLN;
- stock market prices of Rotterdam Coal in USD.

The analyzed time series is relatively brief, yet it effectively captures significant relationships. Of particular interest is its coverage of a period marked by heightened inflation, and understanding potential reasons for this upsurge is crucial. It serves as a foundation for shaping the state's macroeconomic policy. Additionally, the primary statistical analyses are built upon return rate series, mitigating the influence of trends in the data on research outcomes and minimizing the occurrence of spurious correlations.

The statistical analysis of the dataset was rooted in:

- graphical representation of changes in PPI, CPI, electricity, and coal prices on a month-to-month basis, both as single-base indices with a January 2021 base and in the form of month-to-month illustrations;
- determining basic statistics for the time series increments of the analyzed data, including: mean, median, standard deviation, coefficient of variation, minimum, and maximum;
- determining the values of Pearson's correlation coefficient without time delays and with time delays of t+1 and t+2:

$$r = \frac{\frac{1}{(n-i)\sum_{t=1}^{n}(x_t - \bar{x}\,(y_{t+i} - \bar{y})}}{S_x \cdot S_y}$$

$$i = 0, 1, 2$$

where:
$\bar{x}, \bar{y}$ – mean values of increments for variables X and Y,
S_x, S_y – standard deviations of increments for variables X and Y.

The Pearson correlation coefficient enables the assessment of the strength and direction of the linear relationship between two variables. When examining the relationship between energy prices and the level of inflation, we can use the Pearson correlation coefficient to determine if there is a correlated trend between these variables.

- determining the significance level of the t-Student test for the correlation coefficient (without time delays) and the significance level of the Granger test for relationships with time delays of t+1 and t+2.

The Granger significance test was based on two-equation models:

$$x_t = a_1 + \Sigma_i a_{1.i} x_{t-i} + \Sigma_i b_{1.i} y_{t-i},\ i = 1, 2;$$

$$y_t = a_2 + \Sigma_i a_{2.i} x_{t-i} + \Sigma_i b_{2.i} y_{t-i},\ i = 1, 2.$$

The focus was on the second equation. The Granger causality test provides a statistical tool to determine whether past values of a variable (e.g., energy prices) can predict future values of another variable (e.g., inflation levels). By investigating the causal relationship between energy prices and inflation, researchers can discern the direction of influence between these economic indicators. Therefore, the Granger test allows assessing whether it is possible to eliminate variable X in the equation describing the development of variable Y [Kusideł 2000].

The selected methods, due to their properties, could be utilized in scientific research on the interdependen-

cies of various variables. Both the Pearson correlation coefficient and the Granger causality test provide empirical evidence that can support or refute theoretical assumptions about the relationship between energy prices and inflation. This enhances the robustness of research findings and contributes to a deeper understanding of the economic mechanisms at play.

RESULTS

The years 2021–2023, in the wake of two consecutive global crises – the pandemic followed by the war – were relatively unstable, not only economically, but also socially. Uncertainty also affected global energy markets, often leading to drastic changes in prices within short periods. From significant decreases in the initial stages of the pandemic to sharp several hundred percent increases in energy commodity prices and electricity itself in the months following the outbreak of the Russo-Ukrainian War [Kępka and Pająk 2022].

Similarly shaped is the graphical representation of changes in energy prices, coal prices, and inflation levels presented in (Figs 2 and 3). In Fig. 2, the development of coal prices, energy prices, and inflation is depicted as a single-base index with a base of January 2021 = 100, while in Fig. 3, it is illustrated as a chain index, representing the month-to-month ratio to the previous month.

The presented charts (Fig. 2) reveal highly dynamic changes in the selected values during the analyzed period. It is noteworthy that in the cumulative increment chart from January 2021 (Fig. 2), the prices of electricity (TGeBase_Wavg) and coal, depicted on the left side, exhibited a significant surge, reaching a peak in September/October 2022, at a level five times higher compared to January 2021. In the latter part of the examined period, there is a rapid decline in coal and energy prices. The most recent prices are twice as high as at the beginning of the period.

In the chart on the right side (Fig. 2), the values of CPI and PPI inflation are presented, characterized by a dynamic increase compared to January 2021. They reached a peak in February 2023 for PPI and April 2023 for CPI. Therefore, despite the decline in coal and energy prices, inflation did not decrease, but its growth rate slowed down. The period from which the slowdown in inflation is observed suggests a delayed dependence on changes in coal and electricity prices. At the end of the examined period, inflation indices are about a third higher than in January 2021, indicating that the price increase is not as significant as the increase in coal and electricity prices.

Fig. 3 shows month-to-month fluctuations. Interestingly, electricity and coal prices exhibit significantly larger fluctuations than PPI and CPI inflation, as can be seen on the chart axes. The variations in energy

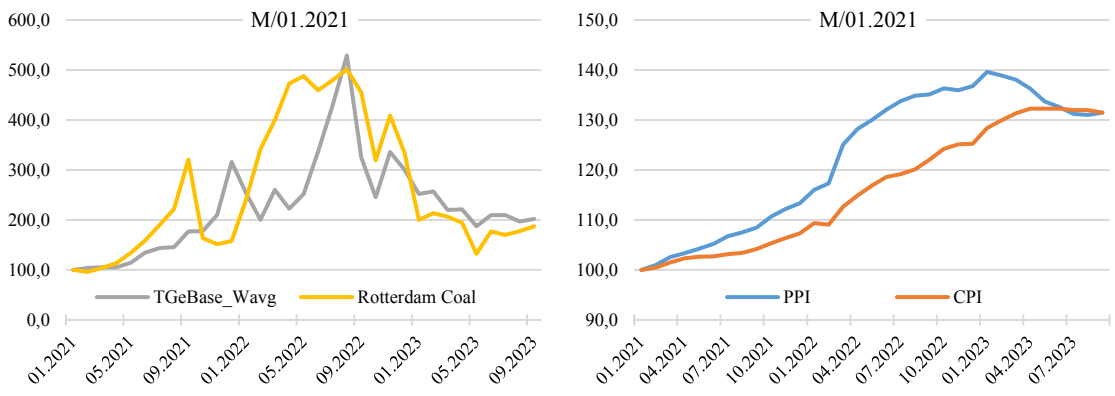


Fig. 2. Fluctuations in electricity, coal and inflation prices in Poland compared to January 2021 = 100 (2021–2023)
Source: own study based on the publicly available data (Statistics Poland and Stock data).

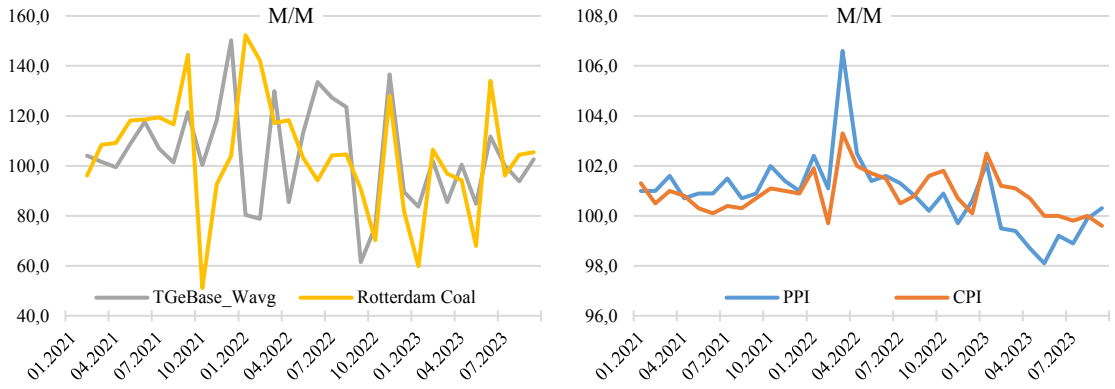


Fig. 3. Monthly fluctuations in electricity, coal and inflation prices in Poland (2021–2023)
Source: own study based on the publicly available data (Statistics Poland and Stock data).

prices are strong and relatively frequent, with monthly fluctuations reaching extreme magnitudes of up to ±50%. In contrast, inflation only experienced one strong fluctuation in March 2022 (6.6% for PPI and 3.3% for CPI on a monthly scale), and since then, the price increases have lost momentum. It is crucial to note, as depicted in Figure 3, that fluctuations in energy prices do not seem to directly affect inflation levels within the same time period. For example, the sharpest rise in inflation can be observed around March and April 2022, whereas energy prices, particularly electricity prices, recorded a significant decrease on a monthly basis. On the other hand, it seems that coal prices may indeed impact inflation levels, especially when examining the timeline since the beginning of 2023. Starting from January 2023, most observations of coal prices show negative fluctuations, which is also the case for CPI inflation. As for PPI levels since the beginning of 2023, there is a noticeable regular decline in month-to-month fluctuations.

For the data presented in Fig. 3, basic statistics were also determined (as shown in Table 1).

The values of the presented statistics confirm the dynamic nature of the changes occurring in the analyzed period. It is worth noting that electricity and coal prices experienced the strongest average increase (4–5%) with a very high variability measured by the standard deviation (19–22 p.p.) from month to month. On the other hand, the mean and standard deviation values for inflation were significantly lower, indicat-

Table 1. Basic statistics of selected variables (2021–2023)

M/M	Rotterdam Coal	TGeBade_Wavg (Electricity)	PPI	CPI
Mean	4,71%	4,08%	0,87%	0,86%
SD	22,69 p.p.	19,53 p.p.	1,47 p.p.	0,83 p.p.
V	4,82	4,78	1,69	0,97
Range	101,21 p.p.	88,77 p.p.	8,50 p.p.	3,70 p.p
Median	4,55%	1,81%	0,90%	0,75%
Min	–48,94%	–38,52%	–1,90%	–0,40%
Max	52,27%	50,25%	6,60%	3,30%

Source: own study based on the publicly available data (Statistics Poland and Stock data).

ing relatively more stable and less dynamic changes in these variables during the analyzed period. The minimum and maximum values also exhibit a significant discrepancy between inflation and energy. Coal prices showed the highest peaks of fluctuations, changing from nearly –50% at the minimum point to over 50% at the maximum. This should not be particularly surprising given the market nature of this raw material and its susceptibility to speculative investor behavior. Strong fluctuations in coal prices, in connection with the conditions of the Polish energy sector, could translate into reactions in the form of equally significant fluctuations in electricity prices, subsequently affecting PPI but in the form of less dynamic fluctuations. These, in turn, led to a slow, relatively stable increase in CPI, averaging no more than 1% month-to-month. The extreme values of monthly changes in PPI and CPI indicators range from –1.90% to 6.60% and from –0.40% to 3.30%, respectively.

The assumed relationship presented above, which can be described as a sequence:

coal ➡ electricity ➡ PPI ➡ CPI,

and alternative sequences:

coal ➡ PPI ➡ CPI,
electricity ➡ CPI,

was subjected to statistical analysis expressed by determining the Pearson correlation coefficient and the significance level of the Granger test with lags of t+1 and t+2, as shown in the table below (Table 2). In addition, lags of t+3 and t+4 were also analyzed, but their results are not shown in (Table 2) due to decreasing values in both the Granger causality test and Pearson correlation coefficient.

In the Granger causality test, most of the assumed relationships do not appear prominently. As seen in Table 2, no clear correlation was found between coal prices and electricity prices in Poland, both in the

Table 2. Correlation coefficients and significance levels of selected variables $X \rightarrow Y$

Rotterdam Coal (*X*)	***X*→*Y***	**TGeBase_Wavg (*Y*)**		**Rotterdam Coal (*X*)**	***X*→*Y***	**PPI (*Y*)**	
		correlation coefficient	*p*-value			correlation coefficient	*p*-value
	M/M	0.234	0.197		*M/M*	0.134	0.466
	M/Mt+1	–0.161	0.407		*M/Mt*+1	0.360	0.067
	M/Mt+2	–0.009	0.695		*M/Mt*+2	0.568	0.004
TGeBase_ Wavg (*X*)	***X*→*Y***	**PPI (*Y*)**		**TGeBase_ Wavg (*X*)**	***X*→*Y***	**CPI (*Y*)**	
		correlation coefficient	*p*-value			correlation coefficient	*p*-value
	M/M	0.204	0.262		*M/M*	–0.028	0.880
	M/Mt+1	0.107	0.950		*M/Mt*+1	–0.055	0.799
	M/Mt+2	0.100	0.990		*M/Mt*+2	0.041	0.924
PPI (*X*)	***X*→*Y***	**CPI (*Y*)**					
		correlation coefficient	*p*-value				
	M/M	0.686	0.000				
	M/Mt+1	0.402	0.059				
	M/Mt+2	0.473	0.061				

Source: own study based on the publicly available data (Statistics Poland and Stock data).

contemporaneous period and with time lags. Such a situation may be considered atypical, considering the degree of dependence of the Polish energy sector on coal as a raw material. Similarly, there is no significant relationship between electricity prices and the level of PPI and CPI inflation, indicating a lack of the often suggested influence of electricity prices on inflation. However, it is worth noting that households and a large portion of businesses in Poland use electricity at fixed prices, which undoubtedly contributes to the absence of a visible correlation between inflation and market electricity prices. Additionally, not surprisingly, a high degree of dependence was observed between PPI inflation and CPI inflation, confirmed by low values in the Granger causality test.

On the other hand, what may be perceived as surprising is the observation of a relatively strong association between market fluctuations in coal prices and changes in PPI inflation in the period t+2. Such a relationship suggests that when there are changes in coal prices in the market, inflation reacts accordingly with a two-month delay. Subsequently, due to the statistical connection between PPI and CPI, changes in coal prices also affect the prices of consumer goods and services. This indicates a ripple effect throughout the economy, where changes in coal prices, which are a crucial input across multiple industries, ultimately impact the general cost of living for consumers [Guan et al. 2023]. These findings illuminate the intricate interplay among commodity markets, inflation trends, and consumer price indices, emphasizing the inherent complexity of economic systems and the interconnectedness among diverse sectors within them.

DISCUSSION

The results presented in connection with the research conducted lead to a natural discussion regarding the actual impact of energy prices on the economy. These studies indicate that no specific relationship was observed between market prices of coal and electricity prices in Poland, which may be surprising given the characteristics of the country's electricity generation system. Moreover, it was not found that the market price of electricity significantly influences the country's inflation rate. The lack of a visible correlation does not necessarily mean a real lack of impact of these prices on inflation levels [Liu et al. 2013], due to the dual nature of the market, where a significant portion of electricity consumers depends on the decisions of state authorities regarding prevailing electricity prices. In such a situation, price changes for consumers typically occur at the beginning of the new calendar year, leading to immediate changes in the economy [Liu et al. 2013]. On the other hand, the remaining portion of consumers with various agreements where the electricity price is linked to market quotations constitutes too small a portion to visibly affect changes in inflation at the macroeconomic level [Keles and Yilmaz 2020]. Consequently, for businesses operating with flexible electricity prices, it is in their interest to distribute the impact of electricity price fluctuations over time on the services and products offered [Dussaux and Monjon 2023] to maintain competitiveness compared to competitors operating with fixed electricity prices.

The studies conducted also revealed strong dependencies along the Rotterdam Coal – PPI – CPI line, with the exception of electricity prices. In this context, the findings of the study confirmed the assumptions of many researchers that energy commodity prices have a significant impact on overall prices in the economy [Przekota 2022]. However, it is worth discussing the observed delayed relationship between changes in the market price of coal and the level of PPI inflation, as well as the fact that inflation has been maintained at a relatively high level despite a gradual decline in coal prices since the beginning of 2023. According to Kilian [2008], the phenomenon of maintaining high inflation resulting from a rapid increase in energy prices is relatively normal, especially in highly energy-intensive industries. The high price level may be sustained for reasons beyond energy factors, such as the desire for profit maximization within enterprises, which may be emboldened by the opportunities presented by high inflation to explain the excessive surge in the prices of goods and services [Kilian 2008].

It is worth noting that in the conditions of the 21st-century economy, enterprises should not be significantly dependent on coal, with the exception of a few industries. However, there is a clear correlation between

these variables. This phenomenon can be partially explained by psychological aspects [Ezeaku et al. 2021]. Society, being informed from all sides about potential dangers, threats, and energy resource shortages, tends to make seemingly irrational decisions [Prentice et al. 2022], dramatically increasing demand for, among other things, energy resources. This, in turn, leads to actual shortages in the market while simultaneously driving up prices. Observing these rapid changes in energy resource markets, companies also prepare themselves by increasing their expenditures, which subsequently affects the shaping of prices, both in the case of PPI and CPI inflation [Bardazzi et al. 2015].

CONCLUSIONS

In general, the conducted research has yielded valuable conclusions regarding the pro-inflationary implications of energy prices. Therefore, the initially stated research objective has been achieved, ruling out a direct translation of electricity prices in the market into the prevailing prices in the economy. Nevertheless, the provided results have allowed for the formulation of even more general and specific conclusions. The correlation between PPI and CPI inflation, as indicated by high correlation coefficient values and Granger causality test results, is not surprising. This relationship arises from the interaction between producers and consumers, as well as the objectives of economic activity, such as maintaining profitability. However, the clear link between PPI and CPI could be the basis for further research into the factors that directly influence PPI, which in turn indirectly affects changes in CPI. Examining the factors that directly impact PPI, as suggested by its correlation with CPI, can provide valuable insights into the drivers of producer prices. This understanding not only sheds light on the dynamics of producer-consumer relationships, but also equips policymakers and businesses with crucial information to anticipate and address fluctuations in consumer prices. Therefore, it emphasizes the significance of incorporating both PPI and CPI in economic analyses and policymaking endeavors.

Fluctuations in coal prices, both month-to-month and with delays, do not appear to significantly impact electricity market prices in Poland. This can be attributed to the low correlation coefficient and Granger's causality values. This situation may be related to EU policies on CO_2 emission rights prices, which are determined by market forces. A significant increase in these prices could have a greater impact on electricity prices in a coal-dominant generation system compared to changes in coal prices alone. The relationship between coal and electricity prices should be further examined in terms of the effects of the CO_2 emission rights market.

Fluctuations in market electricity prices, both month-to-month and with delays, do not seem to have a significant impact on inflation levels in Poland. This is due to the very low values obtained for the correlation coefficient and Granger's causality. The absence of a direct relationship between electricity prices and inflation may be attributed to government regulations that impose maximum prices on electricity for most consumers. This regulatory intervention creates a barrier to market forces influencing electricity prices and, consequently, limits the transmission of electricity prices to broader economic indicators such as inflation. Further investigation into the effects of government intervention on electricity pricing dynamics and its implications for inflationary trends is warranted to better understand the observed phenomenon.

A relatively strong correlation has been identified between fluctuations in coal prices and the PPI inflation level in the economy. This correlation is especially noticeable with a two-month delay, as revealed by the results of the correlation coefficient and Granger causality test. There could be several reasons for this dependence, including the behavior of businesses based on stock market data and aspects of crowd psychology, particularly during times of turbulence. However, further research should focus on determining why coal stock market prices have a significant impact on prices in the economy. It is necessary to investigate how business behavior, market reactions to stock market data, and psychological factors may influence this relationship. Analyzing these factors can contribute to a better understanding of economic mechanisms and help develop appropriate policy and business strategies.

REFERENCES

Adi, T.W., Prabowo, E., Prasadjaningsih, O. (2022). Influence of electricity consumption of industrial and business, electricity price, inflation and interest rate on GDP and investments in Indonesia. International Journal of Energy Economics and Policy, 12(3), 331–340. https://doi.org/10.32479/ijeep.13022

Bardazzi, R., Oropallo, F., Pazienza, M.G. (2015). Do manufacturing firms react to energy prices? Evidence from Italy. Energy Economics, 49, 168–181. https://doi.org/10.1016/j.eneco.2015.01.014

Brown, D.P., Tsai, C.H., Zarnikau, J. (2022). Do gentailers charge higher residential electricity prices in the Texas retail electricity market?. The Electricity Journal, 35(4), 107109. https://doi.org/10.1016/j.tej.2022.107109

Caldara, D., Conlisk, S., Iacoviello, M., Penn, M. (2022). The effect of the war in Ukraine on global activity and inflation. FEDS Notes. Washington: Board of Governors of the Federal Reserve System, May 27. https://doi.org/10.17016/2380-7172.3141

Conrad, C. (2023). Speculation in Food and Commodities A Research Report A Critical Discussion of the Econometric Research Method and an Alternative Analysis. International Journal of Economics and Finance, 15(6), 14–26. https://doi.org/10.5539/ijef.v15n6p14

De Gregorio, J. (2012). Commodity prices, monetary policy, and inflation. IMF Economic Review, 60(4), 600–633. https://doi.org/10.1057/imfer.2012.15

Directive (EU) 2019/943 of the European Parliament and of the Council. Retrieved from https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32019R0943 [accessed: 25.03.2024].

Directive (EU) 2019/944 of the European Parliament and of the Council. Retrieved from https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32019L0944 [accessed: 25.03.2024].

Dussaux, D., Monjon, S. (2023). Selling under other skies when energy prices skyrocket: How do the companies adapt their export strategy when energy prices rise? Energy Policy, 183, 113777. https://doi.org/10.1016/j.enpol.2023.113777

Ezeaku, H.C., Asongu, S.A., Nnanna, J. (2021). Volatility of international commodity prices in times of COVID-19: Effects of oil supply and global demand shocks. The extractive industries and society, 8(1), 257–270. https://doi.org/10.1016/j.exis.2020.12.013

Ferrara, L., Metelli, L., Natoli, F., Siena, D. (2021). Questioning the puzzle: fiscal policy, real exchange rate and inflation. Journal of International Economics, 133, 103524. https://doi.org/10.1016/j.jinteco.2021.103524

Gabryś, H. (2020). Elektroenergetyka w Polsce 2020 (Power industry in Poland 2020). Energetyka, 8, 365-373.

Grudziński, Z., Stala-Szlugaj, K., Ozga-Blaschke, U. (2023). Ceny energii elektrycznej na rynku krajowym. Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią PAN, 111, 81-94.

Guan, Y., Yan, J., Shan, Y., Zhou, Y., Hang, Y., Li, R., Liu, Y., Liu, B., Nie, Q., Bruckner, B., Feng, K., Hubacek, K. (2023) Burden of the global energy price crisis on households. Nature Energy, 8(3), 304–316. https://doi.org/10.1038/s41560-023-01209-8

Guenette, J.D., Kenworthy, P.G., Wheeler, C.M. (2022). Implications of the War in Ukraine for the Global Economy. Policy Notes, World Bank. https://doi.org/10.1596/37372

Keles, D., Yilmaz, H.Ü. (2020). Decarbonisation through coal phase-out in Germany and Europe – Impact on emissions, electricity prices and power production. Energy Policy, 141, 111472. https://doi.org/10.1016/j.enpol.2020.111472

Kępka, A., Pająk, N. (2022). Wpływ wojny w Ukrainie na wysokość inflacji w Polsce (The impact of the war in Ukraine on the level of inflation in Poland). Studia Ekonomiczne, Prawne i Administracyjne, 1(4), 59–72. https://doi.org/10.24136/sepia.2022.020

Kilian, L. (2008). The economic effects of energy price shocks. Journal of Economic Literature, 46(4), 871–909. https://doi.org/10.1257/jel.46.4.871

Konstytucja Rzeczypospolitej Polskiej z dnia 2 kwietnia 1997 roku (Constitution of the Republic of Poland of April 2, 1997). Dz.U. z 1997 r. Nr 78, poz. 483 z późn. zm. Retrieved from https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU19970780483/U/D19970483Lj.pdf [accessed: 25.03.2024].

Kusideł, E. (2000). Modele wektorowo-autoregresyjne VAR. Metodologia i zastosowania (VAR vector-autoregressive models. Methodology and applications). Absolwent, Olsztyn.

Leszkiewicz-Kędzior, K. (2014). Asymetryczne dostosowania cenowe na rynku paliw w Polsce (Asymmetric price adjustments on the fuel market in Poland). Wydawnictwo Uniwersytetu Łódzkiego, Łódź. http://dx.doi.org/10.18778/7969-422-8

Liu, M.H., Margaritis, D., Zhang, Y. (2013). Market-driven coal prices and state-administered electricity prices in China. Energy Economics, 40, 167–175. https://doi.org/10.1016/j.eneco.2013.05.021

Loxton, M., Truskett, R., Scarf, B., Sindone, L., Baldry, G., Zhao, Y. (2020). Consumer behaviour during crises: Preliminary research on how coronavirus has manifested consumer panic buying, herd mentality, changing discretionary spending and the role of the media in influencing behaviour. Journal of Risk and Financial Management, 13(8), 166. https://doi.org/10.3390/jrfm13080166

Majone, G. (2019). The rise of the regulatory state in Europe. [In:] W.C. Mueller, V. Wright (eds), The State in Western Europe. Retreat or Redefinition? Routledge, London, 77–101.

Nagy, E.É., Tengely, V. (2018). The external and domestic drivers of inflation: the case study of Hungary. BIS Paper, 100, 149–172.

Prentice, C., Quach, S., Thaichon, P. (2022). Antecedents and consequences of panic buying: The case of COVID-19. International Journal of Consumer Studies, 46(1), 132–146. https://doi.org/10.1111/ijcs.12649

Prokopowicz, D. (2023) Gospodarcze skutki wojny w Ukrainie (Economic consequences of the war in Ukraine). [In:] E. Cieślak, J. Maj, K. Pająk, D. Prokopowicz, A. Radomyski, P. Soroka, P. Śledź (eds), Wybrane aspekty rosyjskiej agresji na Ukrainę w obszarze politycznym, militarnym i gospodarczym (Selected aspects of Russian aggression against Ukraine in the political, military and economic areas). Dom Wydawniczy Elipsa, Warszawa, 284–332.

Przekota, G. (2022). Do high fuel prices pose an obstacle to economic growth? A study for Poland. Energies, 18, 6606. https://doi.org/10.3390/en15186606

Raghutla, C. (2020). The effect of trade openness on economic growth: Some empirical evidence from emerging market economies. Journal of Public Affairs, 20(3), e2081. https://doi.org/10.1002/pa.2081

Report of PSE for 2022 (2023). Zestawienie danych ilościowych dotyczących funkcjonowania KSE w 2022 roku (Summary of quantitative data on the operation of the National Power System in 2022). Polskie Sieci Elektroenergetyczne S.A. Retrieved from https://www.pse.pl/dane-systemowe/funkcjonowanie-kse/raporty-roczne-z-funkcjonowania-kse-za-rok/raporty-za-rok-2022 [accessed: 20.11.2022].

Schlacke, S., Wentzien, H., Thierjung, E. M., Köster, M. (2022). Implementing the EU Climate Law via the 'Fit for 55'package. Oxford Open Energy, 1, oiab002. https://doi.org/10.1093/ooenergy/oiab002

Seremak-Bulge, J., Rembeza, J., Łopaciuk, W., Judziński, B., Jerzak, M., Krzemiński, M., Borek, M. (2006). Ewolucja rynku zbożowego i jej wpływ na proces transmisji cen (Evolution of the grain market and its impact on the price transmission process). Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej – Państwowy Instytut Badawczy, Warszawa.

Sikorska, E. (2021). Jak nie stabilizować cen energii elektrycznej – nieudana ingerencja państwa (How not to stabilize electricity prices – failed state intervention). Kontrola Państwowa, 66.6/I 401, 52–65. https://doi.org/10.53122/ISSN.0452-5027/2021.1.51

Statistics Poland (2023). Retrieved from https://stat.gov.pl [accessed: 22.11.2023]

Stock data (2023). Retrieved from https://stooq.pl/ [accessed: 22.11.2023]

Szkutnik, J., Sobota, R. (2010). Zagadnienie bezpieczeństwa Energetycznego w Polsce w perspektywie do 2030 roku (The issue of energy security in Poland in the perspective of 2030). Rynek Energii, (1), 57–62.

Weber, I.M., Wasner, E. (2023). Sellers' inflation, profits and conflict: why can large firms hike prices in an emergency? Review of Keynesian Economics, 11(2), 183–213. https://doi.org/10.4337/roke.2023.02.05

Widarti, S., Pramajaya, J. (2018). The effect of profit management on company performance. International Journal of Academic Research in Economics and Management Sciences, 7(4), 44–63.

Zarębski, P., Katarzyński, D. (2023). Small Modular Reactors (SMRs) as a Solution for Renewable Energy Gaps: Spatial Analysis for Polish Strategy. Energies, 16(18), 6491. https://doi.org/10.3390/en16186491

Katarzyński D., Przekota G. (2024). Pro-inflationary significance of energy commodity and eletricity price. Acta Sci. Pol. Oeconomia 23 (2), 29–40, DOI: 10.22630/ASPE.2024.23.2.7

PROINFLACYJNE ZNACZENIE CEN SUROWCÓW ENERGETYCZNYCH I ENERGII ELEKTRYCZNEJ

STRESZCZENIE

Cel: Głównym celem tego artykułu było ocenienie wpływu cen energii elektrycznej na ogólny poziom cen w gospodarce. **Metody:** Metodologia badawcza została starannie zaprojektowana, aby obejmować różnorodne narzędzia analityczne. Obejmowała ona graficzną reprezentację danych, podstawowe analizy statystyczne, obliczenia współczynnika korelacji Pearsona z uwzględnieniem opóźnień czasowych oraz zastosowanie testu przyczynowości Grangera. **Wyniki:** Wyniki badania ujawniły znaczące niedoskonałości w mechanizmie rynkowym w kontekście przełożenia cen energii na poziom cen w gospodarce. Wbrew oczekiwaniom przewidywana korelacja między cenami energii elektrycznej a wskaźnikami inflacji (PPI i CPI) okazała się statystycznie nieistotna. Niemniej jednak, w ramach zbadanych zależności, pojawiło się silne i istotne powiązanie między cenami węgla a indeksem inflacji PPI, zwłaszcza z wyraźnym opóźnieniem dwóch miesięcy. **Wnioski:** Wyciągając wnioski z analizy, stało się jasne, że chociaż ceny surowców energetycznych, jak węgiel, nie przekładają się w pełni na ceny energii elektrycznej, a następnie wpływają na inflację, ceny węgla stają się istotnym predyktorem inflacji. Ta obserwacja wskazuje na niedoskonałości w pośrednim etapie cyklu produkcji, co uwydatnia zauważalne niedoskonałości funkcjonowania rynku. Znaczenie tych wyników wykracza poza wąski obszar sektora energetycznego. Zapewniają one szerszą perspektywę na relacje cenowe w gospodarce, podkreślając ograniczony wpływ rynkowej ceny energii elektrycznej na kształtowanie ogólnego poziomu cen. Ta wiedza stanowi istotny i cenny wkład w obszarze badań ekonomicznych, podkreślając wielowarstwowe dynamiki, które leżą u podstaw mechanizmów ustalania cen w złożonym systemie gospodarczym.

Słowa kluczowe: energia, elektryczność, węgiel, CPI, PPI

Acta Sci. Pol.
Oeconomia 23 (2) 2024, 41–53
acta_oeconomia.sggw.pl ISSN 1644-0757 eISSN 2450-047X DOI: 10.22630/ASPE.2024.23.2.8

ORIGINAL PAPER

Received: 07.02.2024
Accepted: 29.03.2024

ENERGY INDEPENDENT CITIES? INVESTMENT ACTIVITY OF CITIES IN THE IMPLEMENTATION OF EU CO-FINANCED PROJECTS IN RENEWABLE ENERGY SOURCES AND ITS CONDITIONS IN POLAND

Agnieszka Kozera✉, Aldona Standar

Poznań University of Life Sciences, Poland

ABSTRACT

Aim: The main objective of the paper is to evaluate the scale, scope, and significance of investments in renewable energy sources by cities in Poland, which were co-financed from EU funds. This assessment will focus on the last two multiannual financial frameworks, namely for the years 2007–2013 and 2014–2020. **Methods:** Empirical studies were conducted based on data from the database of the Ministry of Development Funds and Regional Policy in Poland, the Local Data Bank, and the Ministry of Finance. When investigating the investment activity of towns and cities related to renewable energy sources, basic descriptive statistics methods were applied. Logistic regression was used to identify the primary socio-economic, financial, and environmental conditions. **Results:** In the analyzed period, the role of towns and cities in the realization of renewable energy projects increased, although it is still relatively limited compared to other types of administrative communes. In the multiannual financial framework for 2007–2013, less than one in ten cities executed at least one project, while in the years 2014–2020, more than one in four cities realized at least one project related to the development of renewable energy sources supported by EU funds. The disparity in activity between towns and cities on a regional scale was huge. These investments were more often realized by towns and cities with a lower level of development, serving tourist functions, and experienced in carrying out such investments. Their lower investment activity was influenced by their level of indebtedness. **Conclusions:** So far, one of the main drivers behind the development of renewable energy in urban areas has been the ecological aspect, particularly the improvement of air quality. However, there is now a growing recognition of the importance of energy security.

Key words: green energy, city decarbonization, local investments, municipal management, EU funds, urban commune

JEL codes: H72, O18, R51, R58, Q42

INTRODUCTION

Over 70% of the population of Europe lives in cities, while in Poland, over 60% of the population lives in cities. [Eurostat]. Urbanization influences all areas of development, including economic, social, and environmental aspects. [Neirotti et al. 2014, Hoppe et al. 2015]. The environmental impact of cities is related to considerable energy consumption and high CO_2 emissions, which manifest in air and water pollution [Bibri and Krogstie 2017]. Expansion of cities also leads to the loss of green areas designated for housing development or economic

Agnieszka Kozera https://orcid.org/0000-0002-6370-0026; Aldona Standar https://orcid.org/0000-0001-8491-5360
✉ agnieszka.kozera@up.poznan.pl

activity. Energy is essential for the smooth operation of cities across various sectors, including schools, kindergartens, care centers, offices, and other municipal institutions. Energy is used to run water supply systems, provide street lighting, and power tramways. Power outages can completely paralyze a city's functions. The condition of the energy supply infrastructure and the infrastructure dependent on it also plays a crucial role, not only because urbanization increases the demand for energy [Birbi 2013]. Thus, cities undertake an increasing number of actions aimed at modernizing infrastructure and public utilities to improve the quality of life for their residents, as well as enhancing their competitive advantage [Rogerson 1999, Senlier 2009, De Jong et al. 2015, Zhan et al. 2018, Ferro De Guimarães et al. 2020, Standar et al. 2022]. These actions are in line with the low-emission urban development in view of the pressing need for transition towards low-emission European[1] and – specifically – the Polish economy [Hoppe et al. 2015, Burchard-Dziubińska 2016, Xing et al. 2019, Kozera et al. 2022]. Issues connected with improved energy efficiency, air quality, and the transition to cleaner, locally available renewable energy sources are becoming priorities for local government units, including cities [Bulkeley 2013, Geels 2013]. To date, a major driver for the development of renewable energy sources in urban areas has been connected to environmental protection, specifically the improvement of air quality [see Chen et al. 2023]. At present, energy security is increasingly being considered essential due to the depletion of natural resources and as a solution to the EU energy crisis, which has been worsened by Russia's invasion in Ukraine. In addition to the environmental impacts of generating energy from renewable sources, such as reduced atmospheric CO_2 emissions, the solutions that have been adopted aim to rationalize the costs of purchasing and consuming electricity. Developing the city's own energy sources makes it possible to stabilize energy prices, gain independence from external factors, and ensure energy security and a reliable energy supply for the city. Consequently, the rising energy prices are forcing local governments to search for savings, which can be provided by renewable energy sources. Moreover, the use of renewable energy aligns with the concept of a so-called "smart city" It is a multifaceted term and the "smart environment" is one its six dimensions [Giffinger et al. 2007, 2014]. This segment is frequently mentioned as one of the key features of smart cities. It involves the application of state-of-the-art technologies to ensure the more efficient utilization of energy resources and the reduction of CO_2 emissions [Stawasz and Sikora-Fernandez 2015]. Such cities minimize their environmental impact through infrastructure and urban management, primarily by developing and utilizing renewable energy sources. Local investments, carried out by the local government sector (including cities), play a crucial role in decarbonizing cities and promoting green energy. This is supported by the Polska Net-Zero 2050 report [CKE 2021], which emphasizes the importance of local community involvement in transitioning to renewable energy sources. Given this, local government units, including cities, must assume a key role in this process as they are closest to the residents and have a deep understanding of their needs. They can implement various investments at the local level to support the development of green energy, thereby accelerating sustainable development in the region. These investments can be financed through various EU funds.

The primary aim of this paper is to assess the scale, scope, and importance of investments made by cities in renewable energy sources and co-financed from EU funds, as well as to identify their conditions in Poland in the last two multiannual financial frameworks (i.e., in the years 2007–2013 and 2014–2020). This paper presents several research questions: What is the role of cities in the realization of investment in the development of renewable energy sources? What role is played by regional city centers in the acquisition of EU funds for these investments? What are the primary socio-economic and environmental factors determining the absorption of EU funds for the development of renewable energy sources?

[1] With each successive multiannual financial framework, the EU increasingly focuses on the implementation of measures aimed at the development of low-emission economy, including those related to the development of renewable energy sources. Climate neutrality is to be reached by 2050 [Parlament Europejski 2024]. As early as 2030, greenhouse gas emissions are to be reduced by min. 40% (in relation to the levels in 1990), the share of renewable energy in total energy consumption is to reach min. 32%, and energy efficiency is to be increased by min. 32.5% [2030 Climate & Energy].

The results of the conducted empirical research are both cognitive and applied. Firstly, they fill the cognitive gap regarding the implementation by urban local governments of investments co-financed by EU funds in the field of RES and the conditions of this activity. Secondly, the results of the conducted research are significant for the implementation of future programs in the field of low-carbon economy development, such as the National Reconstruction Plan.

SOURCE MATERIALS AND RESEARCH METHODS

In order to realize the research aim the Ministry of Development Funds and Regional Policy database was searched to identify projects meeting renewable energy criteria in low-carbon economy (priorities: 41 renewable energy: biomass, 39 renewable energy: wind, 40 Renewable energy: solar, 42 renewable energy: hydroelectric, geothermal, and other)[2] within two EU multiannual financial frameworks covering the years 2007–2013 and 2014–2020. Overall, from both of these databases comprising almost 160 thousand projects, a total of 157 were selected. The beneficiaries of these projects were communes with town rights, including towns with county rights. To assess the investment activity of these entities and the conditions determining such activity, a study was designed and divided into two stages. The first stage consisted of assessing the investment activity of towns, focusing on renewable energy sources. This analysis was conducted using basic descriptive statistical methods. The second stage investigated the conditions determining this investment activity using the logit model. In the first stage, the number and total value of realized projects were analyzed both in absolute and relative terms (per 10 000 inhabitants and per 1 km^2 area). Additionally, the percentage of towns acquiring the investigated financial support was estimated for both studied EU financial frameworks. A significance test for dependent variables was applied to verify whether the size of the local government body and the location of the administrative unit have a significant effect on investment activity addressing renewable energy projects. The non-parametric one-way ANOVA on ranks (the Kruskal-Wallis test by ranks) was used because the investigated variables within the distinguished groups did not have a normal distribution, as verified by the Shapiro-Wilk test.

In the second stage of the study, logistic regression was used to identify the primary socio-economic, financial, and environmental conditions that affect investment activity in towns acquiring EU funds for the development of renewable energy sources. Data for analyses in this stage of the study was collected from the Local Data Bank[3] and the Ministry of Finance, which was mainly from 2020. A total of nearly 50 different variables were considered in the research, including 19 variables representing the socio-economic situation, 19 variables representing the financial situation, and 8 environmental variables. The selection of replacement variables for the study was conducted on the basis of merit – a review of the literature and studies by other authors, as well as the authors' research experience. Statistical criteria (i.e., the degree of correlation between variables) were also taken into account. The models that were highly correlated with each other were eliminated. Finally, only the models that formed statistically significant variables were discussed.

Logistic regression is used when the dependent variable is dychotomic (i.e., it takes two values), where value 1 denotes the presence of a given characteristic, while 0 denotes a lack of a given characteristic [Hosmer and Lemenshow 2000]. Investigated local government units (i.e., communes with town rights) were divided into two separate classes:

$$y_{i=}\begin{cases}0 & \text{communes with town rights, which did not realize EU projects related with development of renewable energy sources 51 communes with town rights, which realized EU projects related with development of renewable energy sources}[4]\\ 1 & \text{communes with town rights, which realized EU projects related with development of renewable energy sources}\end{cases}$$

[2] The projects concerning renewable energy sources were identified based on the so-called "Priority Themes" in the years 2007–2013 and Areas of support in the years 2014–2020.

[3] A major barrier to conducting this type of research is the availability of data at the municipal level. There is a particular lack of information on the level and sources of environmental pollution in Polish public statistics.

[4] Considering the two investigated EU financial frameworks jointly.

The logistic function, on which the logistic regression model is based, takes the following form [Hilbe 2009]:

$$f(z) = \frac{e^z}{1 + e^z}$$

This method is applied, for example, in modeling probability of finding the investigated entity (e.g., a town) in a certain state ($Y = 1$, i.e., realizing projects related with development of renewable energy sources), while it also identifies statistically significant factors influencing this probability. Logistic regression makes it possible to calculate probability of such an event (the so-called "probability of success") [Hilbe 2009]:

$$P(y_i = 1/X) = \frac{e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K}}{1 + e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K}},$$

where:

y_i-th ($i = 1,\ldots, n$) observation in the dychotomic explained variable, which takes value 1 or 0,
$k = 1, 2,\ldots, K$
$X_{i1},\ldots, X_{iK}$ – explanatory variables (socio-economic, financial and environmental conditions, respectively),
$P(y_i = 1/X)$ – probability that variable Y takes value 1 for values of explanatory variables,
$X = [X_{iK}, \ldots, X_{iK}]$, i = 1,…, n; $k = 1,\ldots, K$;
$\beta_0, \beta_1, \ldots, \beta_K$ – structural parameters of the model.

Formally, the logistic regression model is a generalized linear model (GLM) in which the logit is a link function. However, the interpretation of a given model differs from that of the linear model. The sign of the parameter at variable X_k defines the direction of the effect of a given variable on Y. Its plus sign indicates that together with an increase in X_k the odds for $Y = 1$ increase, whereas negative values indicate a decrease in the odds for $Y = 1$. In order to interpret values of model parameters, the odds ratio is estimated [Kleinbaum and Klein 2002]:

$$\Psi = \frac{P_i}{1 - P_i}.$$

The odds ratio determines the relative odds for the occurrence of a given event. In the logit regression model, the level of odds may be estimated as a function of independent variables by modeling values of probability. This ratio is simplified to the following form [Kleinbaum and Klein 2002]:

$$\Psi = e^{\beta_0 + \beta_1 x_{1S} + \ldots + \beta_K x_K}.$$

The expression is a relative change in the odds for the occurrence of an event as a result of the action of a factor described by variable X_k, assuming stability of the other variables included in the model. This value is interpreted by comparing it with the value of 1 and expressing the obtained difference in percent. For example, if , then it is stated that the factor described by variable X_k has a stimulating effect on probability of occurrence of a given phenomenon at a stable effect of the other variables included in the model [Cramer 2011].

The fit of the logit model is evaluated based on the chi-square statistic and the so-called "pseudo-R^2 measures" [Maddala 2001], while statistical significance of variables is verified based on the Wald test. Additionally, the predictive power of the models is also assessed. This is done using the measure of the predictive power of the model established based on the validity table (general validity of the model) [Hosmer and Lemeshow 2000].

RESULTS

Assessment of the investment activity of communes with town rights, dedicated to investment projects co-financed from EU funds and allocated to the development of renewable energy sources

Conducted analyses showed that out of the 302 towns investigated within the first financial framework, less than one out of ten towns acquired UE funds allocated to the development of renewable energy sources. However, in the next financial framework, it was more than a quarter of the investigated local government units. Between the years 2007–2014, towns realized a total of 34 projects, amounting to a joint sum of 95 million PLN. In the years 2014–2020, there were as many as 123 projects, totaling over five times the previous amount (PLN 521 million). The negative result for the years 2007–2014 was caused by the fact that only seven out of 16 provinces managed to ac-

quire EU subsidies. There was a huge disparity in the investment activity of towns depending on the region. During the first analyzed financial framework period in the Podlaskie province, 62% of towns realized projects dedicated to the development of renewable energy sources, co-financed by EU funds. In the Podkarpackie, Opolskie, and Lubelskie provinces, it ranged from 30 to 44% of the investigated local government units. In the other regions, very limited activity was observed for the analyzed beneficiaries. In terms of the number of projects, the towns of the Podlaskie province were particularly successful, as they implemented one-third of all projects. A similar percentage was recorded for this province in terms of the value of these investments. However, the highest amount of EU funds allocated to the development of renewable energy sources was absorbed by communes with town rights from the Lubuskie province. Here, only 6 projects jointly amounted to a record PLN 46 million. In relation to the size of the commune, measured both by the number of inhabitants and area, the greatest funds were also acquired by towns from the Lubelskie province (Table 1).

In the successive financial framework (i.e., in the years 2014–2020), the level of investment activity dedicated to renewable energy increased considerably and only in three provinces no towns implemented such

Table 1. Characteristics of projects co-financed from EU funds, realized by communes with town rights and allocated to renewable energy sources in Poland within the financial frameworks for 2007–2013 and 2014–2020

Provinces	2007-2013					2014–2020				
	number of projects	total value (in thous. PLN)	value per 10 thous. inhabitants (in thous. PLN)	value per 1 km² (in thous. pln)	% of towns acquiring projects	number of projects	total value (in thous. PLN)	value per 10 thous. inhabitants (in thous. PLN)	value per 1 km² (in thous. PLN)	% of towns acquiring projects
Dolnośląskie	0	0	0	0	0	0	0	0	0	0.0
Kujawsko-pomorskie	0	0	0	0	0	9	7 578.3	79.5	12.9	41.2
Lubelskie	6	46 048.8	527.6	71.2	30.0	22	91 050.8	1 104.3	140.7	85.0
Lubuskie	0	0	0	0	0	1	639.6	16.1	1.1	11.1
Łódzkie	0	0	0	0	0	3	16 507.0	126.1	19.7	16.7
Małopolskie	0	0	0	0	0	0	0	0	0	0.0
Mazowieckie	1	1 816.0	3.9	0.9	2.9	2	20 941.4	42.4	10.6	5.7
Opolskie	2	1 954.9	88.7	6.8	33.3	0	0	0	0	0.0
Podkarpackie	8	7 511.8	107.2	10.7	43.8	7	62 400.3	919.6	88.9	31.3
Podlaskie	10	29 270.3	492.0	61.0	61.5	12	15 412.8	264.1	32.1	61.5
Pomorskie	4	613.4	4.6	0.7	18.2	2	7 937.6	59.2	8.9	4.6
Śląskie	3	8 048.9	23.9	2.5	4.1	54	263 719.5	830.5	81.4	55.1
Świętokrzyskie	0	0	0	0	0	1	4 366.1	119.8	15.5	20.0
Warmińsko-mazurskie	0	0	0	0	0	5	2 421.9	39.7	6.8	31.3
Wielkopolskie	0	0	0	0	0	3	19 473.1	163.8	24.5	15.8
Zachodniopomorskie	0	0	0	0	0	2	8 620.9	110.3	10.2	9.1
Total for towns	34	95 264	46.7	6.5	9.6	123	521 069.1	258.6	35.4	26.8
Total for communes	237	791 891.4	205.7	2.5	×	926	3 533 985.4	927.8	11.3	×
Share of towns in absorption of EU support (%)	14.35	12.03	×	×	×	13.3	14.7	×	×	×

Source: the authors' study based on data [Zasady działania…, GUS and BDL].

support. However, in this case, the concentration of EU aid allocated to the development of green energy was even higher. Towns in the Śląskie province had the highest activity indicators in absolute terms, absorbing as much as 43% of the total number of investment projects, which is equivalent to almost half of the town projects in that period. Once again, local government units from the Lubelskie province took a leading position among the most active entities. This province accumulated the highest number of such investments, considering the number of inhabitants or unit area (Table 1).

The results presented above suggest that there may be statistically significant differences between the EU aid acquired by towns allocated to renewable energy sources in individual provinces. The non-parametric analysis of variance confirmed this thesis (Table 2). Further post-hoc analysis revealed that the significance of these differences was influenced by the results recorded for towns from the Lubelskie, Podlaskie, and Śląskie provinces. The local government units from the Śląskie province, namely Zawiercie and Tarnowskie Góry, were the most effective beneficiaries, with each receiving as much as PLN 70 million for renewable energy sources.

Compared to other types of administrative communes, towns realized approximately 13% of projects aimed at developing renewable energy sources, absorbing 14% of EU funds allocated for that purpose. Although these percentages are relatively small, it is important to note that the number of towns is also relatively small compared to other types of administrative communes. Furthermore, towns themselves are not a homogeneous group of local government units in terms of their population. There are towns with several thousand inhabitants and others with populations 100 or even 1000 times larger, such as the capital, Warsaw. Interestingly, regional centers, which are the capitals of Polish regions (called *województwa* in Polish), received relatively small EU funds for projects related to renewable energy sources. Their share of projects in the total number was as low as 5%, and the funds they received accounted for only 2%. Studies conducted by Standar et al. [2022] have shown that the largest cities, which are regional centers, are leaders in implementing projects related to transitioning to low-emission in Poland. Therefore, the study investigated whether the size of a town is reflected in the EU funds acquired for investments in renewable energy sources. It was found that the results were not statistically significant, indicating that every town, regardless of its size, was an effective beneficiary. Therefore, other factors may influence this type of activity (Table 2). Based on the above, the second part of the study focused on identifying these conditions.

Modeling the investment activity of communes with town rights in the realization of investment projects co-financed by EU funds, allocated to the development of renewable energy sources

The process of acquiring EU projects dedicated to the development of renewable energy sources by

Table 2. Results of ANOVA on ranks (the Kruskal-Wallis test by ranks) for indicators of investment activity of towns, co-financed from EU funds and allocated to renewable energy sources in Poland within the financial frameworks for 2007–2013 and 2014–2020

Ling variable	Variable	ANOVA on ranks (Kruskal-Wallis test)	Significance level
size of local government unit*	number of projects	1.4323	$p = 0.4888$
	total value of projects	1.729	$p = 0.4214$
province	number of projects	6.1152	$p = 0.0001$
	total value of projects	108.9619	$p = 0.0001$

*measured by the number of inhabitants, with towns being divided into three groups: up to 20 thous. inhabitants, from 20 to 100 thous. inhabitants and those over 100 thous. inhabitants.

Source: the authors' elaboration based on [Zasady działania…].

towns and other local government units is determined by many factors. Thus, three logistic regression models were developed, illustrating the effect of socio-economic, financial, and environmental factors, respectively, on the investment activity of towns in the acquisition of projects dedicated to green energy and co-financed with EU funds. The results of the estimated logistic regression models are presented in Table 3.The estimated models showed good fit to empirical data, as well as high statistical significance of investigated parameters at explanatory variables.

The conducted empirical analyses showed that among the socio-economic factors, the investment activity of towns related to the acquisition of projects dedicated to renewable energy sources and co-financed from EU funds jointly in the two studied financial frameworks recorded a significant effect for the demographic situation, the level of entrepreneurship, the number of people working on farms, the level of education of town councilors, and the level of tourism development. The conducted empirical studies showed that the increasing value of the explanatory variables, such as the percentage of town councilors with university education or the number of hotel beds in tourist accommodation per 10 thousand inhabitants, resulted in an increased probability of the town acquiring projects dedicated to renewable energy sources co-financed from EU funds. The development potential of a commune is directly dependent on the activity of local government bodies of communes in acquiring funds for development, with their success being dependent, first of all, on qualified staff. Additionally, towns that are tourist resorts are concerned about air quality and focus on the development of green energy infrastructure. Factors stimulating the investigated phenomenon also include the number of individuals working on farms per 1 thousand people of working age. An increase in their number results in increased probability of acquiring renewable energy projects by towns (Table 3).

In turn, the increasing number of enterprises per 10 thousand people has led to a reduced likelihood of towns acquiring and implementing green energy projects. This means that the size and socio-economic development of a town have no significant impact on its ability to secure EU funds for renewable energy development, despite the greater need for such funds in larger towns due to higher levels of air pollution and CO_2 emissions. As a result, smaller towns with lower entrepreneurial standards or a relatively significant agricultural role also prioritize the social and economic benefits that investments in green energy can provide. These benefits primarily include the potential to create additional stable jobs for less skilled workers and stimulate economic activity in both urban and suburban areas. Furthermore, the conducted analyses have revealed that the financial factors influencing towns' investment activity in renewable energy projects co-financed by EU funds are primarily related to their own income potential and overall investment activity, including the acquisition of EU funds. As mentioned earlier, renewable energy projects co-financed by EU funds are more commonly undertaken by towns with lower levels of development. The results of the estimated logit model regarding financial conditions indicate that the higher a town's income potential (measured by per capita income), the lower the probability of acquiring EU funds for co-financing renewable energy projects. Conversely, towns with greater investment activity (measured by the proportion of capital expenditure to total expenditure), including those receiving EU funds for EU projects, demonstrate a higher likelihood of realizing such projects (Table 3). This highlights the significance of the beneficiary's experience in the EU funding acquisition process. Additionally, the level of indebtedness of towns decreases the probability of obtaining and implementing renewable energy projects co-financed by EU funds. Common law regulations specify limits on the indebtedness of local government entities, which then impact their potential for financing or co-financing public tasks using retransferred sources, as well as their ability to apply for debt funds [Dworakowska 2016, Kozera 2017].

In the third group of environmental factors, the in-

[5] Empirical data showing conditions for investment activity of towns related to renewable energy sources came mainly from 2020. This study investigated jointly almost 50 different variables, including 19 variables illustrating the socio-economic situation, 19 variables presenting the financial situation and eight environmental variables. Finally, only those models were discussed, which constituted statistically significant variables.

Table 3. Results of estimation for parameters of logit models developed for investment activity of towns dedicated to renewable energy sources and co-financed from EU funds in Poland within the financial frameworks for 2007–2013 and 2014–2020

Explanatory (independent) variables		Coefficient	Std. Error	Odds ratio	p-values	Relevance [b]
Socio-economic [c]	Change in the number of residents per 1000 inhabitants (total for 2007–2020)	–0.0050	0.0027	0.9950	0.0632	*
	Entities registered in REGON business register per 10 thous. Inhabitants of working age	–0.0014	0.0003	0.9986	<0.0001	***
	Percentage of town councilors with university education (%)	0.0382	0.0096	1.0390	<0.0001	***
	Hotel beds per Refer to earlier comments regarding numbers. inhabitants	0.0002	0.0001	1.0002	0.0119	**
	Number of people working on family farms per 1000 people of working age	0.0207	0.0084	1.0209	0.0136	**
Financial [d]	const	–0.0857	0.5905	0.9178	0.8846	
	Own income per capita (in PLN)	–0.0004	0.0002	0.9996	0.0550	*
	Share of capital expenditure in total expenditure (%)	0.0962	0.0270	1.1010	0.0004	***
	EU funds for financing of programs and EU projects per capita in the years 2014–2019 (in PLN)	0.0003	0.0001	1.0003	0.0204	**
	Total liabilities per capita (in PLN)	–0.0003	0.0002	0.9997	0.0263	**
Environmental [e]	const	2.2355	0.8866	9.3509	2.5210	**
	Forest cover (%)	–0.0241	0.0096	0.9762	−2.497	**
	Developed and urbanized land (%)	–0.0344	0.0136	0.9661	−2.538	**
	Water consumption per capita (in m^3)	0.0541	0.0297	1.0556	1.8230	*
	Consumption of electricity per capita (kWh)	–0.0031	0.0012	0.9969	−2.637	***

Models were constructed based on balanced samples (95 communes, which in the investigated period acquired min. 1 project dedicated to renewable energy sources co-financed from EU funds (1) and 95 communes, which showed no investment activity in this respect (0)); If p-value ≤0.001 it is flagged with three stars (***), 0.001 <p-value ≤0.05 – two stars (**), 0.05 < p-value ≤ 0.1 – one star (*); c) Joint test for model coefficients: $\chi^2 = 40.3$, $p = 0.000$, number of accurate prediction cases = 67.7%; d) Joint test for model coefficients: $\chi^2 = 26.8$, p = 0.000, number of accurate prediction cases = 64.7%; e) Joint test for model coefficients: $\chi^2 =$ =18.2, $p = 0.000$, number of accurate prediction cases = 58.4%.

Source: the authors' calculations using the Gretl program based on data from [Zasady działania…, GUS and BDL, Ministerstwo Finansów 2021].

vestment activity of towns related to the development of green energy supported by EU funds was influenced by several variables. These variables included the percentage of developed and urbanized land (%) and forested area (%), as well as the consumption of electricity and water per capita. However, among these factors, only a higher water consumption per capita was found to be associated with a greater likelihood of acquiring a project co-financed from EU funds and dedicated to renewable energy sources. On the other hand, a higher share of developed and urbanized land, as well as forested areas, resulted in a lower probability of acquiring the analyzed projects by commune local government bodies (Table 3). It may be stated here that greater awareness regarding investments in renewable energy sources is observed in towns with well-developed industries, as this sector consumes as much as 74% of water [Hosmer and Lemeshow 2000]. This confirms earlier results regarding spatial variation in the absorption of EU funds for renewable energy sources, with towns from the Śląskie province leading the way. However, it is worth noting that effective beneficiaries also included towns that are currently at an early stage of development, rather than

just those that are already highly developed. We can expect a greater commitment to participating in green solutions and initiatives in locations where the standard of development is highest, and therefore where the needs are also greatest.

DISCUSSION

That renewable energy positively influences urban development is indisputable [Hoang 2021]. As Szlufik [2017] points out, using renewable energy makes it possible to create a healthy and clean environment for future generations. Polish local governments are only now beginning the transformation, often based on the experience of other countries that have been undertaking these projects for a long time. An example is the German city of Wörrstadt, which has been supplying 100% of its energy from RES for many years [Jachimiuk 2011]. European cities are setting further important pro-environmental challenges, such as Copenhagen, which has set a target of achieving 100% energy neutrality by 2025. Other Danish cities have similar ambitious goals, as do cities in Finland, Norway, and the United States [Hagos et al. 2014, Barbiére 2015, Thellufsen and Lund 2016, Jacobson et al. 2018, Thellufsen et al. 2020].

Czyżak et al. [2021] indicate that the RES potential in Poland is sufficient to achieve the EU climate targets in the 2030 perspective. However, in order for this to happen, certain issues related to RES development need to be resolved. These include unblocking the development of wind power plants, creating incentives for the construction of energy storage facilities, adopting a program for the development of biogas plants (particularly important in rural areas), obtaining funding for the energy transition, and addressing legal instability. Financial or institutional barriers are highlighted by Eleftheriadis and Anagnostopoulou [2015] and Polzin and team [2016], among others. In Poland, as noted by Slotwinski [2022], legal conditions at the national level are currently an inhibiting factor for the direct active participation of municipalities in the generation and supply of energy from RES, especially to cover their own energy needs. The entire bureaucratic process related to new investments in renewable energy also needs to be streamlined. As Kubiczek and Smoleń [2023] note, despite the financial and technical challenges, it is necessary to accelerate the modernization of electricity networks, even going beyond the plans contained in the Charter for the Efficient Transformation of the Distribution Networks of the Polish Energy Sector [URE 2022].

CONCLUSIONS

In light of climate change, the geopolitical situation, and increased energy demand, we may observe a growing interest in cheap and renewable energy sources. For this reason, the development of renewable energy sources is a priority in the EU's strategy for achieving climate neutrality by 2050, and it is one of the pillars of the European Green Deal. The European Union supports the development of renewable energy sources and provides co-financing for such investments, as necessary, considering their capital intensity. In Poland, these funds are allocated to local government bodies, including the basic tier – communes. This is because local government is one of the largest energy consumers in the areas they administer, especially in communes with town rights, where they may also be significant energy producers. Among all types of communes, towns generate the highest energy demand and often face greater environmental pollution. As a result, they should focus on seizing the opportunity to acquire EU funds that support energy transformation in their area. Renewable energy infrastructure can also be successfully implemented in urban spaces.

Based on the conducted analyses, it may be stated that interest in renewable energy projects co-financed from EU funds is increasing among Polish towns and cities with each successive financial framework. In the years 2007–2013, only one in ten towns (and only in seven regions) received such support. However, in the 2014–2020 financial framework, more than a quarter of towns (in 13 regions) received this support. Not only did the percentage of towns implementing these projects increase, but there was also an increase in the number of projects (almost three times more) and their value (a five-fold increase). However, it should be noted that there is a significant and growing concentration of renewable energy projects. The regions with the highest investment activity in communes with

town rights for the acquisition and implementation of projects dedicated to renewable energy development were the Podlaskie and Lubelskie provinces. In terms of the number and value of projects, towns in the Śląskie province were the most successful. The obtained results indicate that there may be statistically significant differences in the EU support received by towns in individual provinces for the development of renewable energy sources. The conducted non-parametric analysis of variance confirmed this hypothesis, and the in-depth post-hoc analysis showed that this is due to the high activity of towns in the aforementioned provinces: Podlaskie, Lubelskie, and Śląskie.

In turn, the estimated logit models identified significant socio-economic, financial, and environmental factors influencing the activity of towns dedicated to investments in the development of renewable energy sources co-financed from EU funds. Among the socio-economic conditions, a significant role was played, among other things, by the percentage of town councilors with a university education, as well as the number of hotel beds per 10 thousand inhabitants. Higher values of these indexes resulted in a greater probability of acquisition and realization of projects developing green energy resources in towns. A factor stimulating this phenomenon also included the number of people working on farms per 1000 people of working age. It indicates considerable potential for the development of renewable energy sources in rural areas located within towns, where not only large wind farms may be constructed, but also biomass may be utilized. In turn, the increasing number of enterprises per 10 thousand inhabitants caused a decrease in the probability of acquiring and realizing green energy projects by towns. This means that the size of a town, the standard of its socio-economic development had no significant effect on the acquisition of EU funds for the development of renewable energy sources. Among financial factors, the level of own income potential and the level of town indebtedness proved significant. At the same time, these analyses showed that towns with a greater investment activity (quantified by the share of capital expenditure in total expenditure), including those acquiring EU funds for the realization of EU projects, were characterized by a greater probability of realizing such projects. Again, this shows the importance of the beneficiary's experience in the EU subsidy application process. In turn, among the last, third group of environmental factors, only greater water consumption per capita resulted in a greater probability, while a higher share of developed and urbanized land as well as forested area led to a lesser probability of acquiring these projects by towns. It may be stated that greater awareness of investments in renewable energy sources is found in towns with well-developed industry, since water consumption is greater there. This confirms earlier results concerning spatial disparity in the absorption of EU funds for renewable energy sources, with towns from the Śląskie province being leaders. At the same time, effective beneficiaries were towns being still at an early stage of development, not necessarily those best developed. Diversification and decentralization of energy generation should concern not only rural areas and small towns but also larger urban centers. We may expect greater commitment and involvement in green initiatives and solutions on the part of towns, where the development is most advanced and as a result the needs are also greatest. Nowadays, it seems that no city mayor needs to be persuaded to obtain EU funds, as the financial and material effects of investments made with their participation are noticeable. Rather, they need to be persuaded to build urban policy in a sustainable (i.e., also pro-environmental) way. This is important because local authorities are not only able to carry out such actions themselves, but through the programs they introduce, they can encourage inhabitants or companies to take joint action. This study, therefore, forms the basis for a broader discussion on the implementation of the energy transition, the use of EU funds for this purpose, and the role of local authorities in this process.

REFERENCES

2030 Climate & Energy Framework. Climate Action. European Commision. Retrieved from https://ec.europa.eu/clima/policies/strategies/2030_pl [accessed 10.10.2023].

Barbiére, C. (2015). 700 cities promise renewable energy transition by 2050. EuractiveFr. Retrieved from https://www.euractiv.com/section/climate-environment/news/700-cities-promise-renewable-energy-transition-by-2050/ [accessed: 19.03.2024].

Bibri, S.E., Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. Sustainable Cities and Society, 31, 183–212. https://doi.org/10.1016/j.scs.2017.02.016

Bulkeley, H., Castan-Broto, V., Hodson, M., Marvin, S. (2013). Cities and low carbon transitions. Routledge, New York – London.

Burchard-Dziubińska, M. (2016). Gospodarka niskoemisyjna w mieście (Low-emission economy in the city), [In:] A. Rzeńca (ed.), EkoMiasto# środowisko. zrównoważony, inteligentny i partycypacyjny rozwój miasta (EcoCity # environment. sustainable, intelligent and participatory city development). Wydawnictwo Uniwersytetu Łódzkiego, Łódź, 165–189.

Chen, X.H., Tee, K., Elnahass, M., Ahmed, R. (2023). Assessing the environmental impacts of renewable energy sources: A case study on air pollution and carbon emissions in China. Journal of Environmental Management, 345, 118525. https://doi.org/10.1016/j.jenvman.2023.118525

CKE (2021). Polska Net-Zero 2050. Podręcznik transformacji energetycznej dla samorządów. Centrum Analiz Klimatyczno-Energetycznych, Warszawa. Retreived from https://climatecake.ios.edu.pl/wp-content/uploads/2022/01/Polska-net-zero.-Podrecznik-transformacji-energetycznej-dla-samorzadow..pdf [accessed: 19.03.2024].

Cramer, J.S. (2011). Logit Models from Economics and Other Fields. Cambridge University Press, Cambridge.

Czyżak, P., Sikorski, M., Wrona, A. (2021). Co po węglu? Potencjał OZE w Polsce (What's next for coal? The potential of renewable energy in Poland). Instrat Policy Paper 06/2021. Retrieved from https://www.instrat.pl/wp-content/uploads/2021/06/Instrat-Co-po-w%C4%99glu.pdf [accessed: 19.03.2024].

De Jong, M., Joss, S., Schraven, D., Zhan, C., Weijnen, M. (2015). Sustainable-smart-resilient-low carbon-eco-knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. Journal of Cleaner Production, 109, 25–38. https://doi.org/10.1016/j.jclepro.2015.02.004

Dembicka-Niemiec, A., Szafranek-Stefaniuk, E., Kalinichenko, A. (2023). Structural and investment funds of the European Union as an instrument for creating a low-carbon economy by selected companies of the energy sector in Poland. Energies, 16, 2031. https://doi.org/10.3390/en16042031

Dworakowska, M. (2016). Limity zadłużenia jednostek samorządu terytorialnego w zmieniającym się otoczeniu gospodarczym (Debt limits of local government units in the changing economic environment). Economic Problems of Services, 125, 137–148. https://doi.org/10.18276/epu.2016

Eleftheriadis, I.M., Anagnostopoulou., E.G. (2015). Identifying barriers in the diffusion of renewable energy sources. Energy Policy, 80, 153–164.

Eurostat. Retrived from https://ec.europa.eu/eurostat/data/database [accessed: 01.10.2023].

Ferro De Guimarães, F. C., Severo, E.A., Felix Júnior, L.A., Leite Batista Da Costa, W.P., Tasso Salmoria, F. (2020). Governance and quality of life in smart cities: Towards sustainable development goals. Journal of Cleaner Production, 253, 119926. https://doi.org/10.1016/j.jclepro.2019.119926

Geels, F. (2013). The role of cities in technological transitions: analytical clarifications and historical examples. [In:] H. Bulkeley, V. Castan-Broto, M. Hodson, S. Marvin (eds), Cities and low carbon transitions. Routledge, New York – London, 13–28.

Giffinger, R., Fertner, C., Kramar, H., Pichler-Milanović, N., Meijers, E. (2007). Smart Cities, Ranking of European Medium-Sized Cities. Research Report. Vienna University of Technology. Retrieved from https://www.smart-cities.eu/download/smart_cities_final_report.pdf [accessed: 19.03.2024].

Giffinger, R., Kramar, H., Haindlmaier, G., Strohmayer, F. (2014). European Smart Cities 3.0. University of Technology, Vienna. Retrieved from https://www.smart-cities.eu/?cid=01&ver=3 [accessed: 19.03.2024].

GUS, BDL. Retrieved from https://bdl.stat.gov.pl/bdl [accessed: 10.09.2023].

Hagos, D.A., Gebremedhin, A., Zethraeus, B. (2014). Towards a flexible energy system – a case study for Inland Norway. Applied Energy, 130, 41–50. https://doi.org/10.1016/j.apenergy.2014.05.022

Hilbe, J.M. (2009). Logistic Regression Models. Chapman & Hall/CRC Press, Boca Raton.

Hoang, A.T., Pham, V.V., Nguyen, X.P. (2021). Integrating renewable sources into energy system for smart city as a sagacious strategy towards clean and sustainable process. Journal of Cleaner Production, (305), 127161. https://doi.org/10.1016/j.jclepro.2021.127161

Hoppe, T., van Bueren, E. (2015). Guest editorial: governing the challenges of climate change and energy transition in cities. Energy, Sustainability and Society, 5, 19. https://doi.org/10.1186/s13705-015-0047-7

Hosmer, D.W., Lemeshow, S. (2000). Applied logistic regression. Wiley & Sons, New York. Retreived from https://www.wodkany.pl/zuzycie-wody-w-polsce [accessed: 13.10.2023].

International Energy Agency World Energy Outlook, IEA Paris (2022). Retrieved from https://www.iea.org/reports/world-energy-outlook-2022 [accessed: 10.10.2023].

Jacobson, M.Z., Cameron, M.A., Hennessy, E.M., Petkov I., Meyer, C.B., Gambhir, T.K. (2018). 100% clean and renewable Wind, Water, and Sunlight (WWS) all-sector energy roadmaps for 53 towns and cities in North America. Sustainable Cities and Society, 42, 22–37. https://doi.org/10.1016/j.scs.2018.06.031

Juchimiuk, J. (2011). Odnawialne źródła energii wizytówką innowacyjnego miasta – Worrstadt, Bydgoszcz, Częstochowa, Szczawnica (Renewable energy sources – the showcase of an innovative city – Worrstadt, Bydgoszcz, Częstochowa, Szczawnica). Przegląd Budowlany, 82(9), 23–29.

Kleinbaum, D.G., Klein, M. (2002). Logistic regression. Springer, New York.

Kozera, A. (2017). Rosnące zadłużenie jednostek samorządu terytorialnego jako zagrożenie dla rozwoju lokalnego (Growing debt of local government units as a threat to local development). Nierówności Społeczne a Wzrost Gospodarczy, 49, 203–215. https://doi.org/10.15584/nsawg.2017.1.16

Kozera, A., Satoła, Ł., Standar, A., Dworakowska-Raj, M. (2022). Regional diversity of low-carbon investment support from EU funds in the 2014–2020 financial perspective based on the example of Polish municipalities. Renewable and Sustainable Energy Reviews, 168, 112863. https://doi.org/10.1016/j.rser.2022.112863

Kubiczek, P., Smoleń, M. (2023). Polski nie stać na średnie ambicje. Oszczędności dzięki szybkiemu rozwojowi OZE do 2030 r. (Poland cannot afford average ambitions. Savings thanks to the rapid development of renewable energy by 2030). Instrat Policy Paper 03/2023. Retrieved from https://instrat.pl/wp-content/uploads/2023/03/Instrat-Policy-Paper-03-2023-Polskie-stac-na-srednie-ambicje.pdf [accessed: 19.03.2024].

Ministerstwo Finansów (2021). Wskaźniki do oceny sytuacji finansowej JST w latach 2018–2020 [Indicators for assessing the financial situation of local government units in 2018-2020]. Retrieved from https://www.gov.pl/web/finanse/wskazniki-do-oceny-sytuacji-finansowej-jednostek-samorzadu-terytorialnego-w-latach-2018-2020 [accessed: 26.09.2023].

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. Cities, 38, 25–36. https://doi.org/10.1016/j.cities.2013.12.010

Parlament Europejski (2024). Polityka energetyczna: zasady ogólne (Energy policy: general principles). Retrieved from https://www.europarl.europa.eu/ftu/pdf/pl/FTU_2.4.7.pdf [accessed: 10.10.2023].

Polzin, F.P., von Flotow, P., Klerkx, L. (2016). Addressing barriers to eco-innovation: Exploring the finance mobilisation functions of institutional innovation intermediaries. Technological Forecasting and Social Change, 103(C), 34–46.

Rogerson, R.J. (1999). Quality of life and city competitiveness. Urban studies, 36(5–6), 969–985. https://doi.org/10.1080/0042098993303

Senlier, N., Yildiz, R., Aktaş, E.D.A (2009). Perception survey for the evaluation of urban quality of life in Kocaeli and a comparison of the life satisfaction with the European Cities. Social Indicators Research, 94, 213–226. https://doi.org/10.1007/s11205-008-9361-1

Słotwiński, S. (2022). Building energy self-sufficiency of municipalities on the basis of national legal conditions in the theoretical perspective of the Polish legal experiences. Energies, 15(9), 3000. https://doi.org/10.3390/en15093000

Standar, A., Kozera, A., Jabkowski, D. (2022). The role of large cities in the development of low-carbon economy – the example of Poland. Energies, 15, 595. https://doi.org/10.3390/en15020595

Stawasz, D., Sikora-Fernandez, D. (2015). Zarządzanie w polskich miastach zgodne z koncepcją Smart City. (Management in Polish cities in line with the Smart City concept). Placet, Warszawa.

Szlufik, M. (2017). Znaczenie i warunki rozwoju odnawialnych źródeł energii dla stanu środowiska naturalnego i zdrowia publicznego (The importance and conditions for the development of renewable energy sources for the state of the natural environment and public health). Czasopismo Studentów i Doktorantów Wydziału Prawa i Administracji UKSW, (4), 42–51.

Thellufsen, J.Z., Lund, H., Sorknæs, P., Østergaard, P.A., Chang, M., Drysdale, D., Nielsen, S., Djørup, S.R., Sperling. K. (2020). Smart energy cities in a 100% renewable energy context. Renewable and Sustainable Energy Reviews, (129), 109922. https://doi.org/10.1016/j.rser.2020.109922

Thellufsen, J.Z., Lund, H. (2016). Roles of local and national energy systems in the integration of renewable energy. Applied Energy, 183, 419–429. https://10.1016/j.apenergy.2016.09.005

URE (2022). Karta Efektywnej Transformacji Sieci Dystrybucyjnych Polskiej Energetyki (Charter for the Effective Transformation of Distribution Networks of the Polish Energy Industry.). Urząd Regulacji Energetyki.

Retrieved from https://www.ure.gov.pl/pl/urzad/informacje-ogolne/aktualnosci/10630,Rynek-energii-elektrycznej-historyczne-porozumienie-sektorowe-regulatora-i-opera.html [accessed: 19.03.2024].

Xing, K., Wiedmann, T., Newton, P., Huang, B., Pullen, S. (2019). Development of low-carbon urban forms - concepts, tools and scenario analysis. [In:] P. Newton, D. Prasad, A. Sproul, S. White (eds). Decarbonising the built environment. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-13-7940-6_12

Zasady działania funduszy 2014–2020 (Operating principles for 2014–2020). Ministerstwo Rozwoju i Inwestycji w Polsce. Retrieved from https://www.funduszeeuropejskie.gov.pl/strony/o-funduszach/zasady-dzialania-funduszy/ [accessed: 27.07.2023].

Zhan, C., De Jong, M., De Bruijn, H. (2018). Funding sustainable cities: a comparative study of Sino-Singapore Tianjin Eco-City and Shenzhen International Low-Carbon City. Sustainability, 10, 4256. https://doi.org/10.3390/su10114256

NIEZALEŻNE ENERGETYCZNIE MIASTA? AKTYWNOŚĆ INWESTYCYJNA MIAST W ZAKRESIE REALIZACJI PROJEKTÓW WSPÓŁFINANSOWANYCH ZE ŚRODKÓW UE W ZAKRESIE ODNAWIALNYCH ŹRÓDEŁ ENERGII I JEJ UWARUNKOWANIA W POLSCE

STRESZCZENIE

Cel: Celem głównym artykułu jest ocena skali, zakresu i znaczenia inwestycji miast w odnawialne źródła energii (OZE) współfinansowanych ze środków UE oraz identyfikacja ich uwarunkowań w Polsce w dwóch ostatnich perspektywach finansowych, tj. w latach 2007–2013 i 2014–2020. **Metody:** Badania empiryczne przeprowadzono na podstawie danych pochodzących z bazy Ministerstwa Funduszy i Polityki Regionalnej, Banku Danych Lokalnych Głównego Urzędu Statystycznego oraz Ministerstwa Finansów. W badaniu oceny aktywności inwestycyjnej miast w zakresie OZE wykorzystano podstawowe metody statystyki opisowej, a w celu identyfikacji jej głównych uwarunkowań społeczno-ekonomicznych, finansowych i środowiskowych regresję logistyczną. **Wyniki:** W badanym okresie zwiększyła się rola miast w zakresie realizacji projektów związanych z OZE, choć jest ona nadal stosunkowo niewielka na tle pozostałych typów administracyjnych gmin. W perspektywie finansowej 2007–2013 niespełna co dziesiąte miasto, natomiast w latach 2014–2020 już ponad, co czwarte miasto zrealizowało przynajmniej jeden projekt związany z rozwojem OZE przy wsparciu środków pochodzących z UE. Dyspersja pomiędzy aktywnością miast w ujęciu regionalnym była olbrzymia. Inwestycje te częściej realizowały miasta o niższym poziomie rozwoju, pełniące funkcje turystyczne, mające doświadczenie w zakresie realizacji tego typu inwestycji, a czynnikiem mającym wpływ na niższą aktywność inwestycyjną miast miał ich poziom zadłużenia. **Wnioski:** Do tej pory jednym z głównych czynników rozwoju OZE na obszarach miejskich był aspekt ekologiczny, związany z poprawą jakości powietrza, natomiast obecnie pod uwagę brany jest coraz częściej aspekt bezpieczeństwa energetycznego.

Słowa kluczowe: zielona energia, dekarbonizacja miast, inwestycje lokalne, gospodarka komunalna, środki unijne, gminy miejskie

CONTENTS
SPIS TREŚCI

FOR AUTHORS

Oeconomia is one of several series of *Acta Scientiarum Polonorum*, a scientific journal founded in 2001 by the rectors of Polish agricultural universities, supervised by the Program Board – representatives of these universities.

The quarterly *Acta Scientiarum Polonorum. Oeconomi*a (ISSN 1644-0757; e-ISSN 2450-047X) publishes original scientific papers covering issues in economics and related fields, including management, agricultural economics, economic geography and other. Articles are published only in English with Polish translation of the title, abstract and keywords.

Current information on the terms and conditions of article publication can be found at the Author Panel at:
https://aspe.sggw.edu.pl/

We answer all questions at:
acta_oeconomia@sggw.edu.pl