REPORT
OF THE SGH WARSAW SCHOOL OF ECONOMICS AND THE ECONOMIC FORUM 2022

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SGH

Report
of the SGH Warsaw School of Economics
and the Economic Forum 2022

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PREFACE

Ladies and Gentlemen,

It is with great pleasure that we present to you already the fifth edition of the *Report of SGH Warsaw School of Economics and the Economic Forum* – one of the most important cyclical publications addressing social and economic changes in the Central and Eastern Europe.

On the pages of the *Report*, published each year since 2018, and on our numerous panels held at the Economic Forum, we have been discussing major phenomena and trends, as well as risks and challenges that the countries of our region have to face in social, economic, and business terms.

Sadly, the recent months have brought a lot of difficult events. We have not managed to recover from the COVID-19 pandemic, when on 24 February Russian Federation invaded Ukraine, expanding the scope of offensive actions carried out against the country since 2014, including the annexation of Crimea. This coincided with circumstances such as high inflation, problems with availability of energy commodities and falling public sentiment. In this year's edition of the *Report*, experts of the Warsaw School of Economics analyse the impact of these events on individual countries of Central and Eastern Europe, and assess their consequences in short- and long-term perspective.

This year's *Report of SGH Warsaw School of Economics and the Economic Forum* provides not only a comprehensive analysis of changes experienced by our part of Europe during the last year, but also, more importantly, it indicates future measures that should help us to overcome at least some of the current problems.

Professor of SGH Piotr Wachowiak, PhD
Rector of SGH Warsaw School of Economics

Zygmunt Berdychowski
Chairman of the Programme Board of the Economic Forum

INTRODUCTION

It is with great pleasure that we present to you the fifth edition of the *Report of SGH and the Economic Forum*, prepared especially for this year's Economic Forum in Karpacz.

The aim of the *Report* is to help business leaders, representatives of administration and local governments, as well as non-government organisations to take decisions in a more efficient manner in the turbulent time of war in Ukraine, high inflation rate and falling public sentiment. The current edition of the *Report* contains eleven chapters, dealing with, among other things, inflation, housing availability, energy transition and other key challenges faced by the citizens and businesses of Central and Eastern Europe (CEE). Individual phenomena are considered both in macroeconomic view and in the light of challenges faced by specific industries (e.g.. pharmaceutical, trade, automotive, energy).

In the first chapter, *Differentiation of inflation rates in the European Union vs. labour markets and economic growth – lessons from the COVID-19 pandemic*, SGH experts prove that, because of the COVID-19 pandemic, the rate of economic activity in the entire European Union (EU) fell in 2020 by over 6%. The depth of the recession in this case was almost twice bigger in the "old" EU economies (EU-14) than in the new Member States from the Central and Eastern Europe (CEE-11). In the second year of the pandemic, when the character of the persisting crisis was already anticipated, the EU states' economies started to pick up. GDP growth in 2021 for the EU as a whole was on average 5.4%, and the growth rate was higher than that of CEE-11, but lower than in the EU-14. The authors highlight that in the conditions of the COVID-19 pandemic and related phenomena, such as recession and economic slowdown, unemployment in CEE-11 remained low, which may indicate that the economic policy implemented there was relatively effective from the point of view of jobs protection.

In the chapter *Central and Eastern European economies during and after COVID-19 crisis* the authors show that in terms of the volume of funds assigned to counter the COVID-19 pandemic, excluding liquidity support, Poland is in the middle of the

CEE ranking. They also analyse additional spending for healthcare, which in Poland were the lowest in the entire region (0.6% of GDP compared to the average 1.9% of GDP in CEE).

The third chapter, *Financial affordability of housing in Central and Eastern European countries amid changes in monetary policy* presents data proving that the rate of decline in the availability of housing loans in CEE can be even 50%, as a result of tightening monetary policy. By the end of 2021, the highest real estate prices were in Czech Republic, where the average price per square metre of residential space reached EUR 3 thousand, while the cheapest housing was in Bulgaria (EUR 0.7 thousand) and Hungary (EUR 1.2 thousand). Housing prices in Poland were close to the regional average, i.e. EUR 1.5 thousand per square metre. It should be also noted that affordability of housing in CEE countries (except Romania) in the last years was systematically falling. In 2021 Poland's housing affordability index was the closest to the region's average – for an average annual income its citizen could buy 9.6 m^2.

In the chapter *Energy transition of automobility – global trends and national perspectives* the team of SGH experts present a base scenario projecting gradual increase in the fleet of zero-emission passenger cars (BEVs) from approximately 40 thousand by the end of February 2022 to about 66 thousand by the end of 2022, and to as much as about 174 thousand in 2030. By the end of the third decade of the 21st century around one million zero-emission passenger cars will be used in Poland (approx. 5% of all vehicles). They argue that the development of public charging stations is a technology factor of critical significance from the perspective of increasing the number of zero-emission vehicles used in Poland.

The chapter *Transposition of supplies and flows of the petrochemical industry in Europe – the state and resource conditions of sustainable supply chains and circular economy* discusses changes and trends in the European flow of petrochemical goods, including plastic, in connection with the disrupted global supply chains. Replacing plastics by substitutes may prove difficult, thus the need to outline changes conforming with the 3R circularity principle (*reduce, reuse, recycle*).

The next chapter, *Impact of energy prices on inflation processes in the economies of Central and Eastern Europe*, its authors reflect on the CEE's dependence on imported energy in the years 2000–2020, which increased in this period by 1.6 pp, compared to 13 pp growth in EU-27. In 2017, 96.5% of total supplies of crude oil and petroleum products consumed in the region came from imports. The empirical analysis also confirms the relation between energy prices and inflation in the CEE countries.

In the chapter *Energy sector in times of price shocks and hybrid warfare,* the authors make an interesting observation that Poland, due to proper evaluation of various dimensions of geo-strategic risk, has gained considerable advantage in developing infrastructure that diversifies directions of gas imports, compared to Member States of the "old" EU.

The study entitled *Innovativeness and competitiveness of the health and pharmaceutical sector* describes visible convergence of not only Polish, but mostly Chinese economy in terms of innovation abilities and innovation position in relation to the EU and USA. Moreover, Polish pharmaceutical industry is a leader in terms of the share of its pharmaceutical companies in the sector.

Authors of the chapter *The role of leasing in financing enterprise investments in Central and Eastern European countries. Current state and future trends* observe that the value of the lease market in CEE has been consistently growing in recent years, to reach EUR 63.6 billion in 2019. In 2020, because of the COVID-19 pandemic and related restrictions, the value of lease companies' portfolio fell to EUR 61.2 billion. At the same time, the Polish market is the CEE leader in terms of value of companies' portfolio (54.5–59.1% of the values of national portfolios in the region in 2016–2020). The authors also highlight that among eight available forms of business financing in most CEE countries (Croatia, Estonia, Hungary, Latvia, Lithuania, Poland) business lease is the most common. In the rest of the region (except Albania) it is the second most popular source of financing.

The subject of the article *The new world of shopping – trends and challenges for trade in Poland and Central and Eastern Europe* is an analysis and assessment of challenges for trade in Poland and CEE, evaluation of structural changes and trends shaping the trade sector, in particular food trade, in the face of transformation of its functioning conditions, as well as prediction of ensuing transitions in the industry, taking into account changing competencies of trade sector workers and post-pandemic economic condition of the region. The authors highlight that between 2021 and 2022 the growth rate of sales on the retail market increased in Poland, Slovakia, and Hungary.

The last chapter, entitled *Systems of support for start-ups in the countries of Central and Eastern Europe*, analyses solutions applied to support start-ups in 13 countries of the Central and Eastern Europe (Albania, Bulgaria, Croatia, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia, Slovenia, Hungary, Ukraine). It is a follow-up of the research carried out in 2019, 2020 and 2021. This year the leaders of support for start-ups in our region are Estonia and Lithuania. Poland fell from the third to fourth position.

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DIFFERENTIATION OF INFLATION RATES IN THE EUROPEAN UNION VS. LABOUR MARKETS AND ECONOMIC GROWTH – LESSONS FROM THE COVID-19 PANDEMIC

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Abstract

The study addresses the dilemmas faced by EU countries in terms of economic and health protection policy during the COVID-19 pandemic in 2020–2021, with a special focus on the 11 new Member States from Central and Eastern Europe (CEE-11). In particular, it includes an analysis of the three basic dimensions of economic performance: economic growth, inflation and unemployment (labour market). Faced with the pandemic, EU governments have had to choose between protecting human life and health on the one hand, and maintaining jobs (employment) and previous rate of economic activity (economic growth), on the other. However, making any of the economic goals (e.g., sustaining economic growth) a priority for socio-economic policy implied a trade-off with health protection policy, primarily in terms of an increase in excess deaths. Similarly, the policy of employment protection entailed a trade-off with accelerated inflation. Strategies adopted in this area by the EU-27 countries were analysed based on two sacrifice indicators: the coefficient of economic sacrifice and coefficient of health sacrifice. The economic sacrifice coefficient reflects the inverse relationship between the unemployment rate and the inflation rate, and refers in its construction to the Phillips curve. The health, or the so-called Covid sacrifice coefficient, shows the relationship between the relative excess number of deaths caused by COVID-19 and the slowdown in economic growth (the depth of recession). The first part of the study examines the paths of economic growth, inflation and unemployment in Poland and the CEE-11 countries against the backdrop of EU-27, using an original method developed by the authors, i.e. the pentagons of macroeconomic condition. Monetary and fiscal

policies were also scrutinized, as well as the major factors responsible for accelerated inflation in this period and new developments in the EU labour markets.

The second part provides the estimation results of the economic and health sacrifice coefficients. The presented analysis also made it possible to divide the entire EU-27 into country clusters reflecting diverse strategies of the Member States in their struggle against the COVID-19 pandemic and the vastly diversified economic and health effects of this struggle.

Seen from the perspective of economic performance, the COVID-19 pandemic triggered a breakdown of economic growth trajectories hitherto observed in the EU-27 in 2020, with GDP contraction in the EU by more than 6% on average. At the same time, the recession was nearly twice as deep in the economies of the "old" EU as in the CEE-11. In 2021, most EU countries returned to their economic growth trajectories. Under the COVID-19 pandemic, unemployment in the CEE-11 countries (including Poland) remained low. This may mean that economic policies there were relatively effective in terms of jobs protection. The coronavirus shock, on the other hand, entailed a significant acceleration of inflation, especially in 2021. This phenomenon extended to encompass countries in both the "old" and "new" EU, with a tendency to accelerate further in 2022.

Health (Covid) sacrifice ratios were calculated separately for the year 2020 and the 2020–2021 period. In both cases, they turned out to be the lowest in countries embodying the Nordic model of capitalism (Denmark, Finland, and Sweden), and the highest, especially throughout the pandemic period, in countries representing the Mediterranean model of capitalism, and in CEE-11 countries. In general, the group of best performers in terms of their response to the COVID-19 pandemic – both in 2020 and in the entire 2020–2021 period – included in the first place the Scandinavian countries, as well as Ireland, Luxembourg, and Estonia. There, GDP growth in 2020–2021 was higher than the EU-27 median (and the recession in 2020 was milder), and the relative number of excess deaths due to the virus was the lowest. At the other end of the spectrum were the Mediterranean countries and three CEE states (Bulgaria, the Czech Republic and Slovakia). These countries showed the worst possible mix of outcomes: a cumulative GDP decline after two years of the pandemic and a relative number of excess deaths well above the median for the EU-27. This is equivalent to saying that attempts to sustain economic growth there proved ineffective and, worse, came at a very high cost. Poland, along with five other CEE-11 countries, was found in a cluster where economic growth in 2020–2021 was faster than the EU-27 median (and the recession in 2020 – shallower), but the cost of achieving this goal (the relative number of excess deaths) turned out to be above average.

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In this article we try to evaluate major economic effects of the COVID-19 pandemic in the European Union (EU-27) in the years 2020–2021, with special consideration for 11 new Member States from the Central and Eastern Europe (CEE-11). The study used three measures comprising the basic trio of economic performance indicators: economic growth, inflation, and unemployment (or, more broadly; the labour market).

These variables create different interconnections (including feedbacks), which were particularly exposed by the coronavirus shock. The subject of our special interest are interrelations between economic growth (or recession) and demand for jobs (rate of unemployment) and between unemployment and inflation.

The fight with COVID-19 pandemic forced the governments of EU Member States to solve various political dilemmas. One of the most fundamental ones was the choice between protecting human life and health on the one hand, and maintaining jobs (rate of employment) and previous rate of economic activity (economic growth), on the other. However, making any of the economic goals a priority for socio-economic policy implied negative feedback, i.e. a price to be paid for achieving it (e.g. excess deaths as a price for sustaining previous economic growth rate). Also, prioritizing the goal of keeping previous employment in the economic policy entailed an additional cost of increasing the rate of inflation.

Therefore, one of the main objectives of this study is to calculate two sacrifice factors: economic sacrifice coefficient and health sacrifice coefficient. The former reflects the usually inverse relationship between the unemployment rate and the inflation rate and refers in its construction to the Phillips curve. The latter, the so-called Covid sacrifice coefficient, shows the relationship between the relative excess number of deaths caused by COVID-19 and the slowdown in economic growth (the depth of recession).

The structure of the article is as follows. The first part examines the paths of economic growth, inflation and unemployment in Poland and the CEE-11 countries, compared to those of EU-27. For this purpose we used, among other things, the tool known from the previous edition of the *Report*: pentagons of macroeconomic condition [Próchniak et al., 2021]. The tool was also used to evaluate two basic components of macroeconomic policy effected during the pandemic, i.e. fiscal policy, and monetary policy. In this part we also attempt to establish the major reasons for higher inflation rate in EU-27 and to discuss new phenomena and trends that were observed on the European labour markets. The second part provides two estimate sacrifice coefficients, resulting from goals chosen by the EU Member States for the time of the pandemic. The first measure allows for quantifying inverse relationship between unemployment and inflation, or to establish the costs of economic policy aimed mostly at the protection of all jobs. The second measure illustrates the dilemma of choice between maintaining economic growth and employment rate, and protection of health and life of citizens (health sacrifice coefficient). The analysis presented in the second part also made it possible to divide the entire EU-27 into country clusters reflecting diverse strategies of the Member States in their struggle against the COVID-19 pandemic and the vastly diversified economic and health effects of this struggle. The article is concluded with a summary of major findings.

Economic growth, inflation and unemployment in Poland and countries of the Central and Eastern Europe, compared to the European Union in the years 2020–2021

In purely economic terms, the outbreak of the COVID-19 pandemic at the beginning of 2020 was an unprecedented exogenous macroeconomic shock, which had a dramatic impact on the economic performance of EU states in 2020–2021, such as the level of economic activity, rate of economic growth, inflation, and unemployment. Moreover, in its first phase (2020) the shock was of **unanticipated** nature, which for politicians meant that they had to work in the conditions of surprise and high uncertainty. They also had to resort to unconventional methods and instruments of economic policy and, more broadly, policy of social protection against the pandemic. These measures took the form of, among other things, surge in budgetary expenditure and extra monetary stimulation in addition to fiscal policy, in order to protect jobs and mitigate recession. This translated into substantial growth of public finance sector deficit and maintaining negative real interest rates. Economic situation in the EU got even more complicated in the second year of the Covid crisis (2021), as the return to the economic growth path in most countries was accompanied by increase in inflation rate. This in turn forced tightening of monetary policy in 2021 and at the beginning of 2022, which in the future may threaten the strength of economic recovery and result in higher unemployment rate.

Changes in the macroeconomic situation in 2020–2021

Economic growth

In its first, unanticipated phase in 2020, the pandemic caused most of all deep recession and obstruction of economic growth trajectories observed hitherto in the EU. Data illustrating the size of this phenomenon are presented in Table 1.

They show that the rate of economic activity in the entire EU fell in 2020 by over 6%. The depth of the recession in this case was almost twice bigger in the 'old' EU economies (EU-14) than in the new Member States from CEE-11. In terms of national economies, the deepest recession (GDP drop by 9–11%) was experienced by Mediterranean countries: Spain, Greece, and Italy. At the other end of the spectrum were the three Scandinavian countries and Luxembourg, along with Estonia, Lithuania, and Poland, where the GDP fell by not more than 3%. Ireland is a separate case, as it not only avoided recession but even recorded fast economic growth in the crisis year 2020.

A measure of the force of the Covid shock in the economy may also be the deviation of GDP fluctuation rate in 2020 from the mid-term trend, i.e. previous growth trajectory in 2010–2019. Relevant data can be found in the second-last column of Table 1. They show that because of the COVID-19 pandemic EU-27 countries lost only in one year almost 8 pp of the previous growth rate. The decline was slightly smaller in CEE-11 (slightly less than 7 pp) than in EU-14. Against this background, the decrease in economic growth rate in Poland was smaller than both CEE-11 average and EU as a whole.

The biggest losses defined in such way (by more than 9 pp) were recorded by: Malta, Spain, France, Portugal and Italy, and among CEE-11 countries – Croatia. The smallest deviation from the trend line (3–6 pp) was observed in Scandinavian countries, Luxembourg, and the Netherlands. Among CEE-11 only Lithuania could be included in this group.

The cases of Greece and Ireland should be commented additionally. In Greece, the decrease in growth rate smaller than the average for EU-14 and EU-27 was caused by negative GDP growth rate in the entire period of 2010–2019. For Ireland, the decrease in growth rate (–0.4 pp) was only relative – the pandemic caused there only a slight drop in the GDP growth rate, from 6.3% annually to 5.9% in 2020.

Table 1. Economic growth in EU in 2010–2021 (GDP in constant prices)

Country	Average annual growth rate 2010–2019	2019	2020	2021*	Change in GDP 2021/2019	Change in GDP growth rate 2020 / 2010–2019	Change in GDP growth rate 2020–2021 / 2010–2019
Poland	**3.7**	**4.5**	**−2.5**	**5.7**	**3.1**	**−6.2**	**−2.15**
Bulgaria	2.1	4.0	−4.4	4.2	−0.1	−6.5	−2.15
Croatia	1.1	3.5	−8.1	10.4	1.5	−9.2	−0.35
Czech Republic	2.5	3.0	−5.8	3.3	−2.7	−8.3	−3.85
Estonia	3.7	4.1	−3.0	8.3	5.1	−6.7	−1.15
Lithuania	3.6	4.6	−0.1	4.9	4.8	−3.7	−1.25
Latvia	2.5	2.5	−3.8	4.8	0.8	−6.3	−2.10
Romania	3.1	4.2	−3.7	5.9	2.0	−6.8	−2.10
Slovakia	3.0	2.6	−4.4	3.0	−1.5	−7.4	−3.75
Slovenia	1.9	3.3	−4.2	8.1	3.6	−6.1	−0.10
Hungary	2.8	4.6	−4.7	7.1	2.1	−7.5	−1.75
CEE-11	3.1	4.1	−3.7	5.6	1.7	−6.8	−2.2
Austria	1.5	1.5	−6.7	4.5	−2.5	−8.2	−2.75
Belgium	1.6	2.1	−5.7	6.3	0.2	−7.3	−1.5
Cyprus	1.7	5.3	−5.0	5.5	0.2	−6.7	−1.6
Denmark	1.8	2.1	−2.1	4.1	1.9	−3.9	−0.85
Finland	1.2	1.2	−2.3	3.3	0.9	−3.5	−0.75
France	1.4	1.8	−7.9	7.0	−1.5	−9.3	−2.15
Greece	−2.1	1.8	−9.0	8.3	−1.5	−6.9!!	1.4!!
Spain	1.1	2.1	−10.8	5.0	−6.3	−11.9	−4.2
Netherlands	1.5	2.0	−3.8	4.8	0.8	−5.3	−1.1
Ireland	6.3	4.9	5.9	13.5	20.2	−0.4!	3.4!
Luxembourg	2.6	3.3	−1.8	6.9	5.0	−4.4	−0.1
Malta	5.9	5.9	−8.3	9.4	0.3	−14.2	−5.75
Germany	2.0	2.1	−4.6	2.9	−2.0	−6.6	−3.0
Portugal	0.9	2.7	−8.4	4.9	−3.9	−9.3	−2.8
Sweden	2.6	2.0	−2.9	4.8	1.8	−5.5	−1.7
Italy	0.3	0.5	−9.0	6.6	−3.0	−9.3	−1.8
EU-14*	1.3	1.8	−6.9	5.3	−2.1	−8.2	−2.4
EU-27**	1.7	2.3	−6.2	5.4	−1.1	−7.9	−2.3

* Estimates.

** Average weighted by population

Source: self-reported data based on data of Eurostat.

In the second year of the pandemic, when the character of the persisting shock was already anticipated, the EU states' economies started to pick up. GDP growth in 2021 for EU-27 was 5.4%, while the growth rate was higher than the CEE-11 average, but lower than in the "old" EU (EU-14). Poland's growth rate was slightly higher than the average for both CEE-11 and EU-27. Because of such diversified rate of economic recovery, only CEE countries managed to reach the pre-crisis production volume, with some surplus (1.7%), in the two crisis years (2020–2021) In the entire EU-27 GDP in 2021 was by 1.1% lower than in 2019, while in EU-14 the negative difference was 2.1%. The strongest economic upswing after the first pandemic year was observed in Estonia, Lithuania, Slovenia, and Poland (over 3% GDP growth in two years), and among the remaining EU states – in Ireland and Luxembourg. At the other end were ten EU countries in which GDP in 2021 was still lower than in 2019. Only three of them were from the CEE-11 group (Bulgaria, Czech Republic, and Slovakia), the other seven were Western European countries. The biggest losses of growth rate were incurred by Spain and Portugal (GDP decrease by 4–6%), and slightly smaller (around 2–3%) – by Italy, Austria, and Germany.

The cumulative impact of the pandemic on the EU economic growth can also be presented as average annual deviation of GDP fluctuation in 2020–2021 from the 2010–2019 trend line. Relevant data are presented in the last column of Table 1. The loss of growth rate defined in this way was on average 2.3 pp for the entire EU; below-average results were recorded by CEE-11 countries, while above-average results – by the "core" EU. In CEE-11 relatively biggest decline in growth rate was observed in Czech Republic and Slovakia, while in the "core" EU – in Malta, Spain and Germany. Poland's growth rate (–2.15 pp) in that period was slightly better than the average for both CEE-11 and EU as a whole.

Macroeconomic situation

In our evaluation of the impact of the COVID-19 pandemic on the changing economic situation in Poland and other EU-27 countries, apart from separate analysis of economic growth paths, we also applied the pentagons of macroeconomic condition, known from previous editions of the *Report* [Próchniak et al., 2021]. Axes and respective apexes of the pentagons represent a set of variables, three of which refer to economic results for 2020–2021, and the two other – to directions (changes of approach) of fiscal and monetary policies of the EU Member States. The former include results of the analysis, conducted in the previous point, of economic growth paths in the form of GDP, as well as rate of inflation (INF) and unemployment (UNE), which can be interpreted as indicators representing the state of macroeconomic balance. To measure the approach of the fiscal policy, we used the government budget balance (GOV) and for monetary policy – the real equilibrium interest rate (REIR).

Figure 1 shows the pentagons of macroeconomic condition for CEE-11 countries and some countries of the "old" EU representing the Western Europe.

In 2020 inflation in CEE-11 was relatively low (1.5% on average). However, in some countries some trends of fast growth price could be observed. In terms of price stability the best situation in that time was in Estonia, Slovenia, Croatia, and Latvia. Average prices practically had not changed there since 2019. The fastest price growth was in Poland (3.7%), with the highest inflation rate in the entire EU. A similar pace of price growth (over 3%) was also observed in Czech Republic and Hungary.

Inflation in CEE-11 intensified in 2021. The inflation rate there was on average 3.7%, varying from 2.0% in Slovenia to 5.2% in Poland and Hungary. Higher inflation in this region was caused by a combination of various factors, which will be discussed in the next section.

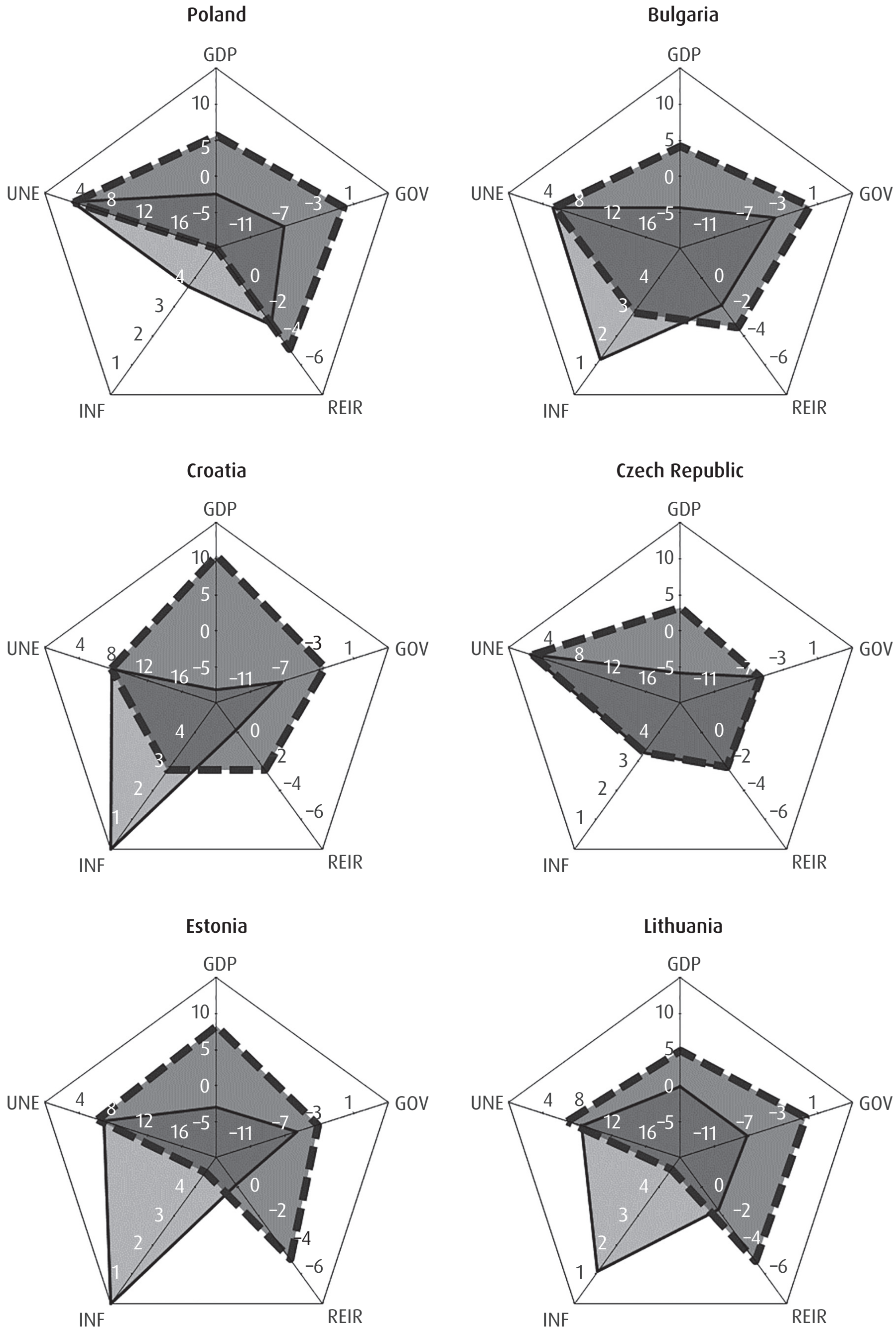
The pentagons clearly show substantial deterioration of macroeconomic indicators for price stability in CEE-11. For 2020 the filled area along the left axis representing inflation was in most cases considerably large, if not full, which indicates that the situation was very good. In 2021 the area filled along this axis shrank, and for some cases it almost disappeared. This confirms rapid growth of inflation in the analysed countries, observed across the entire region.

In 2020 unemployment rate in CEE-11 was one-digit – between 2.6% in Czech Republic and 8.5% in Lithuania. Against this background, the situation on the Polish labour market in 2020 can be considered good. Unemployment at 3.2% suggested that it was close to the natural rate, and involuntary unemployment was practically non-existent. Obviously, low wages are a different issue. In Poland, as in other CEE-11 countries, wages are much lower than in the Western Europe, and differences in pay rates do not fully reflect the differences in work efficiency.

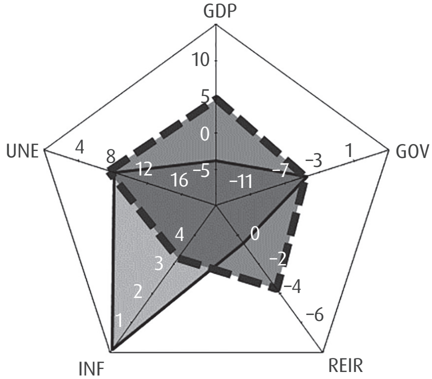
In 2021 unemployment rate in CEE-11 was still low and changed only slightly in relation to 2020.

According to data for the 2020–2021 period, in the conditions of the COVID-19 pandemic with accompanying recession and economic slowdown unemployment in CEE-11 remained low. This may mean that economic policies there were relatively effective from the perspective of the maintenance of jobs.

Figure 1. Economic condition of CEE countries in 2020–2021



Latvia



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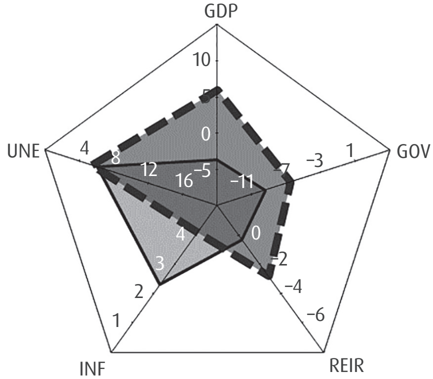

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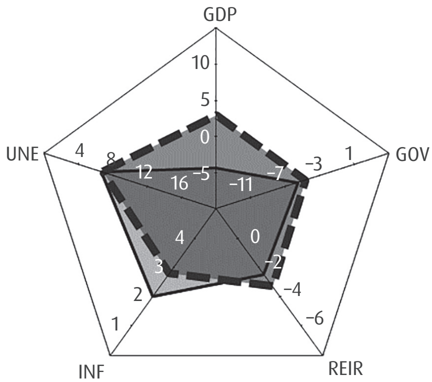

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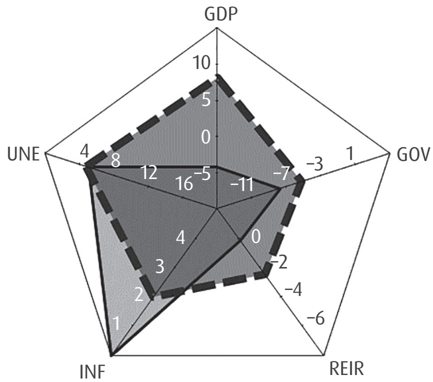

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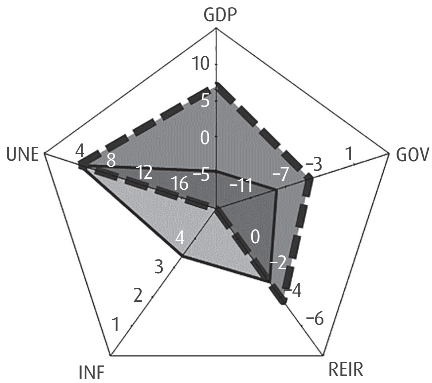

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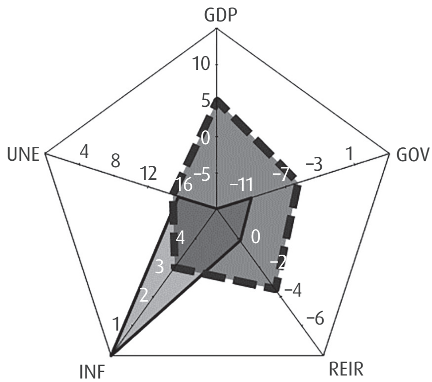
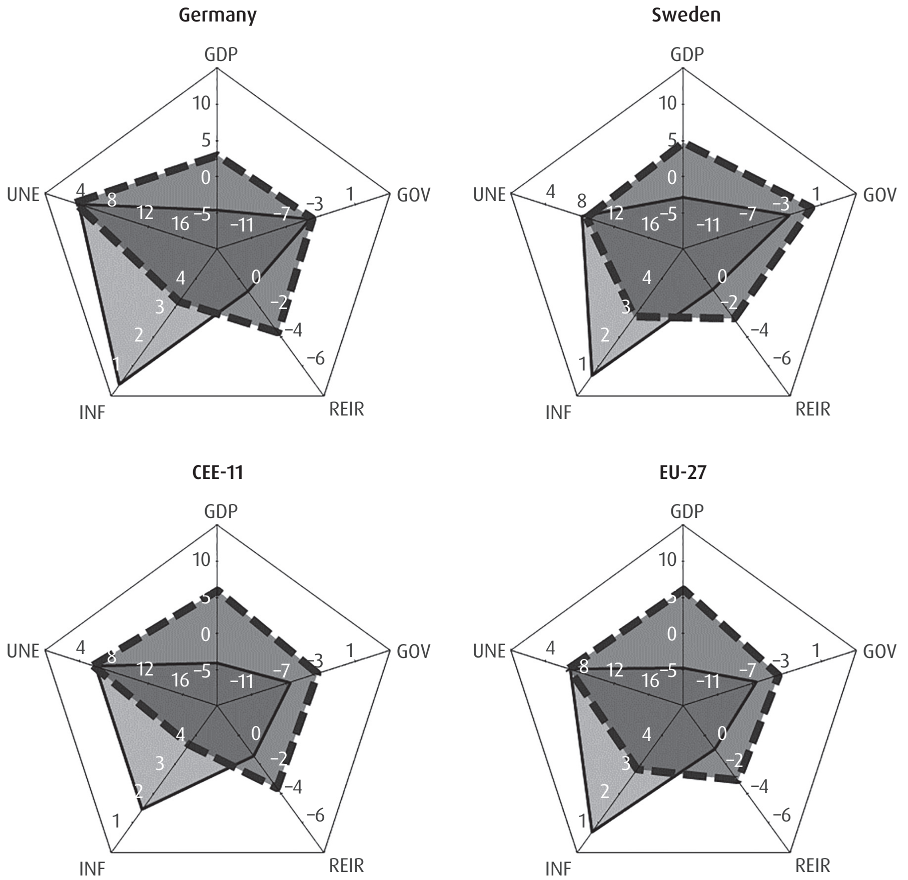




Notes: The pentagon filled with the light-grey colour and delineated with a fine line refers to the year 2020, while dark-grey pentagon delineated by dashed line refers to the year 2021.
Unemployment rate was calculated as arithmetic mean of unemployment rates observed in consecutive months of the relevant year. Government budget balance in 2021 is the average for first three quarters of 2021. Real interest rate was calculated as the difference between nominal interest day-to-day rate of the monetary market (in annual terms), which is an average for individual months, and average annual inflation rate. Due to lack of data, the nominal interest rate for Croatia was assumed equal to the central bank interest rate 3M NRR3 HRK (in annual terms), which is an average for individual quarters. Nominal interest rates for all the euro zone countries are the same.
Data for CEE-11 and EU-27 are unweighted means.
Symbols:
GDP – GDP growth rate (%),
INF – inflation rate (%),
UNE – unemployment rate (%),
GOV – government budget balance (% of GDP),
REIR – real equilibrium interest rate (% of GDP).

Source: self-reported data based on the data of Eurostat.

Comparison of CEE-11 countries with the Western Europe (EU-14) in respect of inflation and unemployment rates exposes the following differences. First, in CEE-11 countries in 2021–2021 the inflation rate was on average higher than in the EU-14. In

2020 in the former group it was on average 1.5%, while in the latter – 0.2% (unweighted mean). In 2021 the rates of inflation were 3.7% and 2.4%, respectively. Second, in both years unemployment rates in EU-14 countries were higher than in CEE-11. In 2020 average unemployment rate in CEE-11 was 5.8%, while in EU-14 it was 7.9% (unweighted mean). In 2021 the rates were 5.5% and 7.7%, respectively. The highest, two-digit unemployment in the Western Europe was recorded in two Mediterranean countries: Greece and Spain.

The impact of the COVID-19 pandemic on the economies of EU Member States was also exerted through economic policy effected in 2020 and 2021. In the first year of the pandemic it mostly took the form of significant easing of the fiscal policy, which manifested itself in a surge in public finance deficit in the EU countries, represented by the right middle apex of the pentagons illustrating their macroeconomic condition. In Poland, the deficit was 7.1% of GDP, slightly exceeding the CEE-11 average (6.5%) and EU-27 average (6.4%). In the entire EU budget deficit was recorded in Spain and Greece (over 10%), as well as France, Italy, Belgium, and Malta (– 10%). In CEE-11, above-average (over 7% of GDP) rise in budget deficit was in 2020 in Romania, Croatia, Slovenia, Lithuania, and Hungary. In these countries their fiscal policy became more expansionary mainly because of greatly increased public expenditure, which was not accompanied by simultaneous increase in budget income. Increased spending at the cost of the budget deficit and national debt was dedicated to protection programmes and anti-crisis shields, aimed at mitigating the adverse effects of the pandemic shock on the economy and maintaining jobs threatened by the pandemic.

The fiscal expansion in 2020 was also somewhat supported by the monetary policy. As the bottom right corner of the pentagons shows, in almost all EU-27 countries real interest rate was negative. On average in 2020 in the EU it was –0.8%; in CEE-11–1.4% and in EU-14–0.6%. The countries in which the rate deviated from the general trend were Greece, Ireland, and Cyprus, and in the CEE-11 group these were Croatia and Estonia. In Poland, such expansionary approach to the monetary policy was much stronger than on average in EU-27 and CEE-11, where the real interest rate was –3.2%; what is more, it dropped significantly in relation to 2019 (from –0.5%).

Let us note here, however, that the Covid crisis, and, more broadly, the situation persisting in the last few years (especially in the euro zone and some other EU Member States) where ECB and national central banks have been maintaining interest rates close to zero or even negative (euro zone), makes it even more difficult to evaluate the nature of monetary policy and its changes from the point of view of a standard real interest rate. That is why our evaluation comprises other, unconventional monetary policy measures applied by ECB and some national central banks (e.g. in Hungary) to aid higher budget spending in order to mitigate the consequences of the pandemic.

These measures in 2020 covered, most of all, asset purchase effected by ECB and national central banks, which was directly translated into monetary base and national money supply.

The combination of expansionary fiscal and monetary policy was supposed to prevent the Covid-induced recession from turning into deeper and prolonged economic crisis – a goal which was successfully attained. On the other hand, the cost of such policy mix was the intensified inflationary pressure in the next year of the pandemic.

It is even more difficult to evaluate unequivocally the macroeconomic policy approach that was assumed in EU in 2021. Mean indicators presented on the pentagons show that most Member States did tighten their fiscal policies and eased their monetary policies. It is proven by the shrinking of the budget deficit by half (both in CEE-11 and EU-14) and further decrease in real interest rates. Particularly spectacular reduction of public finances deficit was observed in Bulgaria, Poland[1], and Lithuania, as well as Denmark, Luxembourg, and Sweden; in some cases the deficit in one year turning into a surplus (Bulgaria, Denmark, and Luxembourg). Still, at the same time some EU countries, such as Belgium, France (where the deficit grew), Greece, Malta, and Italy, had their budget deficit highly destabilized (7–9% of GDP), which may be a sign of maintaining highly expansionary fiscal policy. These trends concurred with further fall in real interest rates, caused by maintaining low nominal interest rates for the subsequent year and/or their insufficient and late rise (e.g. in Poland) when inflation accelerated. Maintaining the expansionary monetary policy in the EU, especially in Poland, in the conditions of evident economic upturn after the first pandemic year and growing inflationary pressure, is evidence of inadequate and much overdue response of monetary authorities to rapidly changing macroeconomic conditions and international situation.

Main determinants of inflation and changes on the labour markets in the European Union in 2020–2021 during the COVID-19 pandemic

Major causes of inflation growth

While seeking causes of rapid growth of inflation in Poland and the rest of EU after the coronavirus pandemic, we should refer to a broad complex of factors that, with various force and in various proportions, were affecting Member State economies

[1] Let us add that the improvement of the public finances in Poland, visible in official statistics, was largely an effect of so-called budgetary accounting, i.e. shifting some public expenditure to non-budgetary funds.

in the years 2020–2021. For the sake of this study they can be grouped into two basic categories:

1) global phenomena affecting all the EU countries;
2) factors specific for individual economies, including Poland.

For the first category it may be useful to divide the main causes of inflation growth into two groups:

a) negative exogenous supply shocks;
b) positive endogenous demand shocks.

Some of the most important sources of **negative exogenous supply shocks** are:

1) disruptions of supply chains in global production networks of multinational corporations, caused by COVID-19; this phenomenon covered especially components and sub-assemblies manufactured in China and South-East Asia; due to limited supply their prices in Europe and Poland rose, pushing up prices of products containing them; effects of these disruptions were delayed in time – they were especially strongly felt in 2021;
2) rise in energy commodity prices triggered in the second half of 2020 and 2021 by the pandemic-affected economies' upturn and surge in demand for crude oil and gas.

The major stimuli driving inflation of **positive endogenous demand shocks** were the following changes in the national (community) economic policy:

1) rapid increase in public spending and budget deficits in EU Member States in 2020, induced by the response of national governments to the pandemic, which in the subsequent year additionally aggravated inflationary effects of exogenous supply shocks;
2) quantitative easing (purchase of financial assets on the secondary market) effected by ECB in the euro zone and by some non-euro zone EU Member States (Hungary), which entailed increasing monetary base and nominal money supply, and in consequence also higher expectations and inflationary pressure.

In **Poland, its specific factors** contributed to the growth of inflation unprecedented in the EU.

First, one of them was excessively generous policy of social transfers, not balanced by adequate production investments and expansion of production capacity of the economy; the policy exacerbated pro-inflationary effect of anti-crisis programmes and shields that were supposed to protect jobs, despite production volume falling in 2020 (lockdown).

Second, a source of growing inflationary pressure was the increasing (especially in the second year of the pandemic) wage-price spiral, which occurred in the conditions of excess demand over supply on the labour market and growing number of bottlenecks in goods production.

Third, a fact that should be particularly highlighted is excessively expansionary monetary policy, inadequate to the changing economic situation in Poland and in the world; its strategy (first interest rate rise) was altered definitely too late – only in autumn 2021.

Fourth, an important factor generating inflation was depreciation of PLN on the foreign exchange market, which translated into higher import costs and additional inflationary pressure.

According to Polish business economists, this group of internal factors, specific for Poland, could be responsible for almost half of the increased inflation in 2021 and Q1 2022 [Pytlarczyk, 2022].

Labour market

First reactions to the COVID-19, such as fear about health and life, were soon accompanied by anxiety connected with worsening economic situation. The first phase of the "pandemic shock" that ended in the fourth quarter of 2020 was connected with restrictions imposed on economic activity, which was supposed to control the virus transmission, but was also a serious hurdle for business. Decline in the economic activity, however short-term, was significant. Some enterprises downsized, other implemented policies of retaining employees, incurring the costs of standstill allowances, still other worked remotely. In any case, the perspective of growing unemployment at a global scale was considered to be one of the largest challenges that the global economy would have to face. In the EU in the second quarter of 2020 almost 5 million people lost jobs. Experts say that this number is still relatively small, considering the rapid reduction of economic activity. A certain "shock absorber" was common introduction of shorter working time. According to research made by the European Trade Union Confederation, by the end of April 2020 almost 42 million applications were filed in the entire EU for support for employees covered by shorter working time schemes, which was equal to about one fourth of total labour force in the EU. The biggest numbers of applications were filed in France, Germany, and Italy.

Consequences of the pandemic affected not only employees who were laid off, but also those who were already unemployed or economically inactive, but wanted to find a job. In the second quarter of 2020 in the entire EU almost 3 million unemployed people found jobs, which was by almost 2 million fewer than in the relevant period of the previous year. This is alarming, because people who cannot find employment for longer time are at risk of permanent exclusion from the labour market. In the first two quarters of 2020 the number of people who permanently withdrew from the labour market was assessed at 7.5 million. Interestingly, such phenomenon was not observed during the 2008 financial crisis Baert, 2021].

The most affected by the consequences of the pandemic in the EU were trade, restaurants, and hospitality, i.e. the sectors offering relatively low pay and part-time employment, hiring many unqualified workers. Notably, those who were hit the most by the pandemic shock, were young people.

In a survey made by the European Foundation for the Improvement of Living and Working Conditions, in the second quarter of 2020 the question "have you lost your job permanently or temporarily during the COVID-19 pandemic" received positive answers from 6.1% of people aged 18–34, 5.3% of people aged 35–49 and 4.7% of people aged over 50 [Eurofound, 2020].

Negative effects of the pandemic shock on the labour market were felt the most by southern European countries: Greece and Spain, and to a smaller extend by France, Italy, and Portugal. Scandinavian countries, CEE, Germany, and the Netherlands were relatively less affected by the pandemic consequences.

Researchers of the International Labour Organisation (ILO) and OECD found the changes on the labour market in 2020 to be signs of progressing segmentation of the labour market. The OECD report shows that employees on permanent employment contracts and fixed-term contracts were less exposed to the risk of job loss than temporary workers and "dependent" self-employed people (providing services for one client) and freelancers. Income inequalities also increased, since job loss, reduced working hours and pay cuts affected mostly workers with precarious contracts, who are mostly young people with low income and people with unstable career paths [OECD, 2021]. These observations are confirmed by the findings of monitoring published by ILO, which indicate that people most exposed to the adverse labour market developments induced by the COVID-19 pandemic are, among others, young people, women, migrant workers, those working in the informal economy and people with disabilities [ILO, 2021].

An important phenomenon on the labour market, strongly associated with the pandemic are commonly applied forms of employment enabling social distance, such as remote work. According to the aforementioned Eurofound research, around 44% of employees were working remotely in 2020 across the EU. Remote work was most popular in Belgium, Denmark, and Italy. The smallest percentage of distance workers was recorded in Bulgaria and Slovakia (Table 2).

Many experts then were of the opinion that remote work will become an alternative for office work in many companies. However, data collected in 2021 (Table 2) show that as the pandemic waves were passing, signs of return to offices were more and more evident. Fully remote work started to be replaced by its hybrid form, or alternate work from home and office work. This information can be interpreted as a sign of return to the pre-pandemic state. It is also proven by the improving general condition of the labour market. Data for the three quarters of 2021 indicate that employment in the EU has recovered to reach the pre-pandemic level [EC, 2021].

The year 2020 was also difficult for the Polish labour market. Severe restrictions introduced in March 2020 immediately translated into the loss of jobs. Enterprises affected by the economic downturn decided not only to downsize, but also to cut wages. Average monthly wage dropped from PLN 5389.58 in February to PLN 5175.58 in April. The following months, nevertheless, brought more optimism, increase in employment and average wage growth in the enterprise sector [GUS, 2021].

Table 2. Percentage of employees in some EU-27 countries declaring remote work in 2020–2021

Country	June/July 2020	February/March 2021
UE-27	44.3	42.2
Austria	45.9	46.1
Belgium	66.4	59.1
Bulgaria	25.4	17.8
Croatia	32.5	29.5
Czech Republic	44.2	29.5
Denmark	57.3	33.9
Estonia	40.5	36.2
Finland	45.8	58.6
France	45.1	49.8
Greece	40.0	31.3
Spain	52.0	39.7
Netherlands	41.3	59.6
Lithuania	44.4	39.1
Latvia	38.1	36.6
Germany	41.1	41.2
Portugal	50.6	47.9
Romania	30.8	27.1
Slovakia	29.8	32.9
Slovenia	36.2	37.7
Sweden	35.1	42.8
Hungary	32.0	28.0
Italy	53.4	44.7

Source: Eurofound [2021].

Despite the fears that the restrictions introduced in the autumn of 2020 with the second wave of the pandemic would have an adverse impact on the Polish labour market, data for 2021 prove that in many respects the situation improved. By the end of 2021, the number of the employed exceeded 16.7 million, which was by over 370 thousand more than in 2020, and by almost 320 thousand more than in 2019. Unemployment rate, which was rising from the start of the pandemic, fell by the end of 2021 by 5.4% [GUS, 2021], to the rate lower than before the pandemic was announced in 2020.

The Polish economy proved to be resilient to the crisis caused by the COVID-19 pandemic, which translated into relatively good performance of the labour market. Unfortunately, structural problems similar to those experienced by most EU countries were not avoided.

According to analyses of the Polish Central Statistical Office (GUS), the pandemic affected mostly the employment situation of young people, which is indicated by fewer working people and worse employment rate than in 2019, and also larger group of economically inactive people. First months of the pandemic saw also a sizeable increase in the number of employees not performing their work, number of part-time workers and people working at home [GUS, 2021].

These observations lead to a conclusion that the most acute effect of the pandemic on the labour markets in the EU will be their structural weakness. It may be therefore presumed that the low unemployment rate will be a “fig leaf” covering structural disturbances.

Authors of the quoted report of the European Commission praise individual countries for their merits in preventing negative consequences of the COVID-19 pandemic on their labour markets.

Many experts reckon that particularly important in dealing with adverse trends on the labour market may be, or, as it seems, already is, cooperation between the state with groups of interest such as employers and trade unions. This measure was successfully applied in Austria, Switzerland, and Germany to design solution allowing firms to operate on a shorter working time basis (*Kurzarbeit*). Businesses thereby retained their previous employees, with shorter working time. For their lost remuneration, an employee received – depending on the duration of such solution – 70% to 80% of their previous salary. They were also promised to have their social security contributions reimbursed. In other countries, such as Bulgaria and Denmark, trilateral agreements between the government, trade unions and employers enabled creation of temporary schemes of salary subsidies. In France, the trade union confederation CFDT participated in negotiations over solidarity fund for the hospitality sector, which suffered the most during the crisis. As a result, employees and employers of this industry were exempted from social security payments for the second quarter of 2020 and received further support irrespective of the employment situation [Benassi, 2020]. The aforementioned measures are merely examples of a broad range of solutions applied by governments in collaboration with their social partners in individual European states.

Based on these observations and available econometric models, ILO experts have reached a conclusion that involvement of social partners in the fight with the pandemic would contribute to higher rate of membership in employee organisations. It has been assessed that probability of increased trade union membership during the COVID-19 pandemic is 26%, provided that the trade unions are visibly involved in the fight with the consequences of the pandemic crisis [Otieno, Wandeda, Mwamadzingo, 2021].

Although statistical data that would prove the thesis mentioned above are hard to find, press information seems to confirm it to some extent. According to research by a Japanese trade union movement announced by the end of 2020, the number of trade union members in Japan rose by the end of 2020, despite a drop in the number of the employed by 940 thousand y/y, due to economic slowdown caused by COVID-19 [Fujikazu, 2021]. In Canada in the first half of 2020 the trade union membership grew to almost 32%, the highest rate in 15 years [Stanford, 2020]. In Great Britain in mid-2021 it was announced that the number of trade union members grew for the first time in many years, particularly in the public sector [Hunt, 2021]. The Swedish branch of UNI Global Union[2] said that in March 2020 it had 5 thousand new members after having negotiated a deal with retail trade employers, which made it possible to avoid lay-offs, and introduced guaranteed pay for employees during the coronavirus pandemic crisis [UNI Global, 2020].

Although these pieces of information do not yet prove any revival of trade union movement, adding the increased number of union members to their engagement in mitigating the effects of the pandemic may encourage them to involve more broadly and actively in the protection of employee interests. A circumstance conducive to such policy is inflation, whose consequences are increasingly palpable in the form of shrinking purchasing power of wages and salaries. The growing wage pressure is a clear signal for trade unions to undertake more resolute actions to protect pay. The symptoms are more and more evident. The head of Verdi, a German trade union in the service sector, said in October 2021 that the growing inflation in Germany requires "clearly palpable real wage growth" [Reuters, 2021]. More or less at the same time the leader of Fórsa, the biggest Irish public administration trade union, said that high inflation will have an impact on pay negotiations [Wall, 2021]. It cannot be excluded that in the near future Europe will face a wave of union protests where people will be demanding higher wages to compensate for the costs of inflation. These will presumably be

2 UNI Global is an international organisation of trade unions from the service and trade sector.

mostly employees of the public sector, who are always the first to suffer the costs of restrictive budgetary policy and whose wages are not linked to market mechanisms. They remain, however, a relatively well organised trade union group, which gives them sizeable real bargaining power.

An attempt to estimate economic and health sacrifice coefficient in the conditions of COVID-19 pandemic

Economic sacrifice coefficient

Economic sacrifice coefficient has been calculated as a quotient of inflation rate change (in percentage points) and similarly defined unemployment rate change. On a standard basis, sacrifice coefficient is calculated as a quotient of unemployment rate change and inflation rate change, which illustrates the costs of the state anti-inflationary policy effected in the form of drop in employment and rise in unemployment. For our study such a definition of sacrifice coefficient would not be reliable, since state governments in the COVID-19 pandemic focused not on anti-inflationary policy, but on protection against recession, decrease in employment and increase in unemployment. The cost of such economic policy was faster inflation growth. Therefore, for the sake of our study, economic sacrifice coefficient is defined in an inverse manner: as a quotient of inflation rate and unemployment rate.

The unemployment rate included in the calculations is the mean of monthly unemployment rates announced by ILO. The inflation rate is taken from Eurostat. The presented calculations refer to EU-27 in the years 2020–2021.

The values of economic sacrifice coefficients for individual EU countries and for its three groups (CEE-11, EU-14, and EU-27) are shown in Table 3.

Interpretation of the data requires additional comment. In order for the study on the relation between inflation and unemployment to be consistent with the Philips curve, economic sacrifice coefficient should be negative. It then shows by how many percentage points would inflation rise if unemployment rate fell by 1 pp or reverse – by how many percentage points would inflation drop if unemployment rate rose by 1 pp. For example, if the economic sacrifice coefficient is –2.0, the decrease in unemployment rate by 1 pp entails increase in inflation rate by 2 pp. If the sacrifice coefficient is in turn positive, then either both inflation rate and unemployment rate fall (which implies no sacrifice whatsoever), or both of them rise.

Clearly, it is difficult to evaluate unequivocally the approach and effectiveness of the economic policy based solely on economic sacrifice coefficients presented in Table 3.

Such analyses should take into account also changes in unemployment rate and inflation rate. Comprehensive interpretation should therefore be based on simultaneous observation of three variables: the direction of change in inflation rate, the direction of change in unemployment rate and economic sacrifice coefficient.

Table 3. Economic sacrifice coefficient – inflation vs unemployment in the EU in the years 2020–2021

Country	2020	2021	Country	2020	2021
Poland	−12.8	7.8	France	2.0	−14.8
Bulgaria	−1.5	11.3	Greece	2.0	−1.2
Croatia	−0.7	162.0	Spain	−0.8	−4.5
Czech Republic	1.3	0.0	Netherlands	−3.8	−2.7
Estonia	−1.2	−7.2	Ireland	−1.6	7.0
Lithuania	−0.5	−2.1	Luxembourg	−1.5	−3.2
Latvia	−1.5	−5.7	Germany	−1.5	−8.8
Romania	−1.4	−2.9	Portugal	−0.9	−1.9
Slovakia	−0.9	12.0	Sweden	−0.7	3.9
Slovenia	−3.7	−11.0	Italy	1.1	9.2
Hungary	0.0	−24.0	Cyprus	−3.0	−20.4
Austria	−0.1	8.0	Malta	−1.0	0.1
Belgium	−4.6	3.8	EŚW−11	−2.1	12.7
Denmark	−0.7	−3.8	UE-14	−0.8	−3.1
Finland	−0.7	−34.0	UE-27	−1.4	2.8

Source: own calculation.

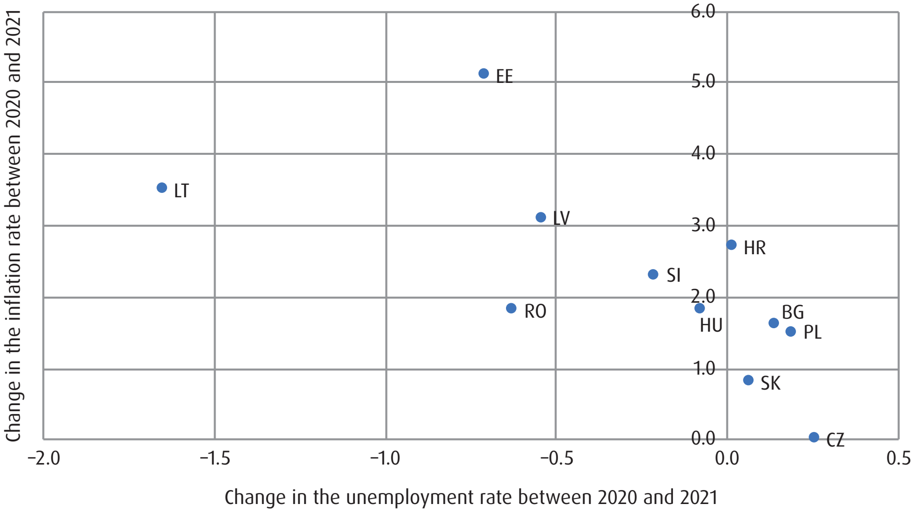
Figures 2 and 3 present directions of changes of inflation and unemployment rates in CEE-11 and EU-27 in 2021.

In the analysis of economic sacrifice coefficient special attention should be paid to the year 2021, as that was when the sacrifice manifested itself (protection of jobs at the cost of higher inflation). Inflation rate in that time rose in 25 EU countries, except Czech Republic (price stabilization) and Malta (inflation rate drop by 0.1 pp). Data used in the figures cover therefore only 2021.

Depending on the direction of changes of inflation and unemployment rates, EU-27 countries can be divided into the following four clusters:

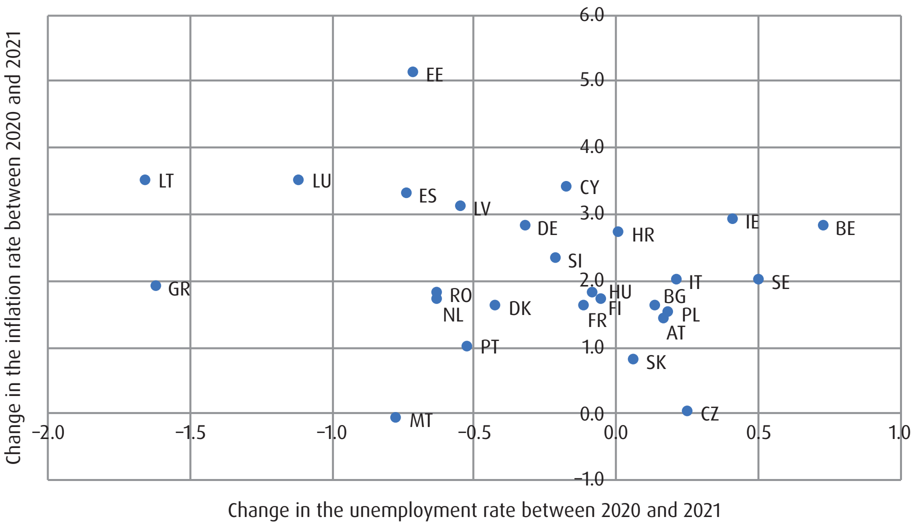
- countries with growing inflation rate and growing unemployment rate;
- countries with growing inflation rate and falling unemployment rate;
- countries with falling inflation rate and growing unemployment rate;
- countries with falling inflation rate and falling unemployment rate.

Figure 2. Change in the unemployment rate and inflation rate in CEE-11 in 2021



Source: self-reported data.

Figure 3. Change in the unemployment rate and inflation rate in EU-27 in 2021



Source: self-reported data.

Extreme cases where no change in one of these values occurred can be included in one of the clusters above. With such categorization, economic sacrifice coefficient estimates will show diversified approach and effectiveness of economic policies of EU Member States among clusters.

Data presented in Figure 2 prove that in 2021 CEE-11 countries (except Czech Republic) recorded growth in inflation rate in relation to 2020. Combined with the criterion of change of unemployment rate direction, this allows for distinguishing two clusters in the CEE-11 group.

The first one, featured by falling unemployment rate and growing inflation rate, comprises: Estonia, Lithuania, Latvia, Romania, Slovenia, and Hungary. These countries improved their situation on the labour market in 2021, which translated into lower unemployment. This was however done at the cost of substantial growth of inflation rate – as shown in Figure 2, inflation in this group of economies was rising much faster than in most CEE-11 countries included in the second cluster.

The second cluster, featured by growing unemployment rate and growing inflation rate, comprises: Bulgaria, Croatia, Czech Republic (with unchanged inflation rate), Poland and Slovakia. In these countries (except Croatia), inflation was growing slower than in the countries from the first cluster.

A comparison of two groups of countries from CEE-11 exposes a certain regularity. In those countries where unemployment in 2021 increased slightly, the rise in inflation was smaller (except Croatia). In those countries, however, where unemployment fell, the increase in inflation was bigger. There is a clear inverse relationship between the sacrifice in the form of faster price rise and maintaining jobs. State policy that was effective in protecting jobs was at the same time stimulating higher inflation.

These observations are confirmed by a statistical analysis. Correlation coefficient between inflation rate and unemployment rate for CEE-11 countries in 2021 was –0.2988. It is negative, but statistically insignificant. This means no statistically significant inverse relationship between the inflation rate and unemployment rate. Correlation coefficient between change in inflation rate and change in unemployment rate was negative (–0.6780) and statistically significant (with significance at 5%). Apparently, data for CEE-11 countries in 2021 confirm the **inverse relationship between inflation rate and unemployment rate**, which implies that the policy of jobs protection was effected at the cost of higher inflation. This finding is a certain novelty against the background of the existing reference literature, and a substantial conclusion from our study.

Expanding the analysis onto the entire EU-27 group proves no statistically significant relationship between inflation and unemployment in 2021. It is presented on Figure 3. It can be observed that in some countries inflation rose by 2–3.5 pp, with unemployment falling by over 1 pp (Lithuania, Luxembourg, and Greece), in other faster inflation growth was combined with unemployment rate growing by 0.4–0.7 pp (Ireland, Sweden, Belgium).

In Poland, the economic sacrifice coefficient was –12.8 in 2020 and 7.8 in 2021. In other words, the unemployment drop by 1 pp recorded in 2020 was connected with increase in inflation rate by 12.8 pp. This means very high cost of jobs protection policy, the highest in the entire EU. In 2021 Poland observed both growing inflation and unemployment: inflation increased by 7.8 pp per 1 pp of unemployment growth. This may be interpreted as a symptom of poor efficiency of economic policy in terms of both labour market and prices stability.

To close this part of the analysis, one more comment on methodology is required. The results of the calculation of economic sacrifice coefficient in the EU in 2020–2021 can only partly be interpreted in line with the standard short-term Phillips curve. That is because it represents quantitative, inverse relationship between unemployment and inflation in "normal" conditions, i.e. within a typical business cycle determined by market mechanisms. Meanwhile, inflationary and labour market processes in the analysed period were driven mostly by a purely exogenous factor, namely the COVID-19 pandemic, which enforced new legal and administrative regulations, ultimately translating into market adjustments (including, among other things, modifications in the global supply chain and the surge in energy commodity prices). This means that our empirical estimates of economic sacrifice coefficient should be interpreted, referring to the economics theory, as a combined effect of four different shocks in 2020–2021: short- and long-term shock and supply and demand shock. Graphically the effect may be presented as a simultaneous upward shift of the Phillips curve (and movement along the new curve) and shift toward the left of the vertical, long-term Phillips curve, which reflects faster inflation growth in the situation of decreased potential production and rising natural unemployment rate.

Health sacrifice coefficient

The goal of this section is primarily to identify choices made in the analysed period by the EU-27 countries in the area of health and economic policies that were supposed to reduce the number of direct and indirect victims of the COVID-19 pandemic on the one hand, and on the other – to limit adverse consequences of this shock for economic growth and GDP (and to keep the previous employment rate).

A variable that to some extent presents the effects of health policies of the EU states is the relative number of excess deaths (established separately for 2020 and aggregately for the entire 2020–2021 period), compared to the average relative number of deaths annually (and for two years' period) in 2010–2019. We are aware that most of such analyses measure the effects of health policies on the basis of relative number of people whose death was classified as a direct consequence of coronavirus infection. This approach, however, does not take into account the fact that classification methods of deaths directly connected with SARS-CoV-2 in EU-27 are strongly diversified. Also, we reckon that the scale of growth of the total relative number of deaths, most of all in CEE-11 (but not only) suggests a strong indirect impact of the pandemic on death rate. It was probably a consequence of much less developed healthcare system (especially hospital treatment), which was not able to provide necessary support to patients with other conditions, because of being completely engaged in the treatment of coronavirus cases. In our view this is the cause of so many excess deaths in some countries, which significantly exceeded the number of deaths caused only by coronavirus.

The effectiveness of the state economic policy is evaluated on the basis of GDP growth rate in 2020 (deviation of GDP growth rate from the trend in the years 2010–2019, just like in the first part of the study) and cumulative GDP growth rate in 2020–2021. This is how we can establish how strong was the deviation of the annual growth rate in 2020 from the previous trend, which enables more synthesized description of economic effects of the pandemic in its first year. The cumulative growth rate for the entire pandemic period (2020–2021) illustrates the consequences of this macroeconomic shock for the GDP rate in the analysed group of countries.

In our analysis of consequences of decisions made by the studied group of countries to mitigate the adverse health and economic effects, we applied two measures. The first one is the **health (Covid) sacrifice coefficient**, calculated in the same manner as the economic sacrifice coefficient in the previous section.

The Covid sacrifice coefficient was calculated for each EU-27 country in two variants: for 2020 in relation to GDP growth rate in 2010–2019, and for the entire two-year period in relation to GDP rates. We thereby obtained two figures:

- the first was the quotient of the relative number of excess deaths (difference between the relative number of deaths in 2020 and the average relative annual number of deaths in the years 2010–2019) and the difference between the 2020 GDP growth rate and the average growth rate in 2010–2019 – **sacrifice coefficient I**;
- the second one is the quotient of the relative number of excess deaths (difference between the relative total number of deaths in the years 2020–2021 and the two-year average relative number of deaths in the years 2010–2019) and cumulative GDP growth rate in the same period – **sacrifice coefficient II**.

We thereby received data on the relative number of deaths (those directly caused by coronavirus and excess ones), which were the cost of drop in the GDP growth rate by 1 pp. (in relation to the average growth rate in 2010–2019) in 2020, as well as on the relative number of deaths (calculated in a parallel way) being the cost of drop in the GDP growth rate by one pp in the years 2020–2021.

Table 4. Covid sacrifice coefficient in the EU in the years 2020–2021

	Sacrifice coefficient I	Sacrifice coefficient II
Poland	**407.02**	**1921.09**
Bulgaria	467.25	−24,178.68
Croatia	206.45	3412.24
Czech Republic	236.00	−1719.93
Estonia	55.98	539.78
Lithuania	522.37	986.02
Latvia	146.97	5380.05
Romania	382.48	3453.74
Slovakia	174.20	−3118.77
Slovenia	349.74	1011.50
Hungary	206.95	2080.97
Austria	113.55	−672.69
Belgium	209.92	6891.35
Cyprus	103.72	8656.68
Denmark	47.78	334.77
Finland	151.60	1265.95
France	139.68	2303.22
Greece	236.30	−2944.86
Spain	156.50	−435.79
Netherlands	248.07	3114.12
Ireland	605.56	40.65
Luxembourg	82.17	87.24
Malta	27.43	1653.65
Germany	155.39	−1209.41
Portugal	192.03	−878.15
Sweden	21.48	−165.61
Italy	261.87	−1338.62
Median	192.03	539.78
Average for EU-27	218.83	239.65
Average for CEE-11	286.86	−930.18
Average for Mediterranean countries	211.68	−1399.35
Average for Scandinavian countries	73.62	478.37
Average for continental countries	135.54	1501.98

Notes: the negative value of the sacrifice coefficient II for Sweden is the consequence of the fact that the relative number of deaths in 2020–2021 there was lower than the average number in 2010–2019, while the cumulative GDP growth rate in the same period was positive. The negative value of the sacrifice coefficient II in nine other countries results from their negative cumulative GDP growth rate in the years 2020–2021.

Source: own calculation based on data of Eurostat.

The analysis of data presented in table 4 gives a basis for two conclusions. First, in 2020 the Covid sacrifice coefficients were low in countries representing the Nordic model of capitalism[3] and extraordinarily high in CEE-11 countries. This means that each percentage point of change in GDP growth rate in Scandinavian countries in the first year of the pandemic (in relation to the previous trend) cost much fewer excess deaths, especially compared to CEE-11 countries (the highest sacrifice coefficients in this group of countries were in Bulgaria, Lithuania, and Poland).

The second conclusion is about the two-year period of the pandemic and also indicates that Scandinavian countries were the most successful in reconciling the highest possible economic growth rate with a low number of excess deaths. Each percentage point of the cumulative GDP growth rate in these countries cost on average only slightly more than 478 excess deaths per million people. The situation of countries with the Mediterranean capitalism model in this respect is much worse, as their drop in GDP by 1 pp in the 2020–2021 period cost on average 1400 excess deaths per million people[4]. For the sake of comparison, this number in Poland was over 1921, which is worse than the EU-27 average, but better than the CEE-11 average.

However, the Covid sacrifice coefficients must be interpreted in a particularly careful manner, taking into account other variables. That is because some of the analysed countries recorded positive, and other – negative cumulative GDP growth rate in the years 2020–2021. Interpretation of the Covid sacrifice coefficient in that period for example for Austria (– 672.69) is totally different than interpretation of its value for Finland (1265.95) or Slovenia (1011.50). For Austria's GDP in 2021 was lower than in 2019, while in Finland and Slovenia it grew. The interpretation is made even harder by the fact that the value of the sacrifice coefficient is low both when a small number of deaths is correlated with moderate decrease in GDP growth rate (as in the case of Scandinavian countries – Table 5), and when a large number of deaths concurs with a GDP slump (as in the case of Mediterranean countries – Table 5). The case of Bulgaria is especially interesting, as its absolute Covid sacrifice coefficient II of 24,178.68 is the highest in the entire analysed group, due to its cumulative GDP growth rate being close to zero (–0.1 pp).

It is therefore pointless to consider the Covid sacrifice coefficients without any reference to the changes in and cumulative GDP growth rate, as well as excess deaths. That is why we applied another measure in the form of **analysis of distribution of the**

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3 The countries were classified in the groups representing different capitalism models pursuant to classification introduced by Amable [2003].

4 The average absolute value of the Covid sacrifice coefficient II for the countries with the continental capitalism model is indeed higher, but the fact that it is positive indicates that the cost of higher number of excess deaths (in relation to the average for Mediterranean capitalism model countries) translated into a positive cumulative growth rate in 2020–2021.

analysed characteristics in relation to the median, which made it possible to identify and analyse diversification of both macroeconomic and health policies in EU-27. We analysed separately the year 2020 and cumulative changes in the two-year period 2020–2021). Each time we took into account not only the change in and the rate of GDP growth, but also the number of excess deaths (relevant columns of Table 5).

Table 5. GDP growth rate and excess deaths in the EU in the years 2020–2021

	Deviation of GDP growth rate in 2020 from the 2010–2019 trend	Relative number of excess deaths in 2020 in relation to the 2010–2019 average	Deviation of GDP growth rate in 2020–2021 from the 2010–2019 trend	Cumulative PKB growth rate in 2020–2021	Relative number of excess deaths in 2020–2021 in relation to the two-year average in the 2010–2019 period
Median for EU-27	−6.74	1307.32	−1.75	0.82	2762.91
Average for EU-27	−7.86	1352.99	−2.27	−1.11	3202.39
Average for CEE-11	−6.78	1837.85	−2.21	1.68	5105.14
Average for Mediterranean countries	−10.03	1924.92	−2.50	−4.18	3616.73
Average for Scandinavian countries	−4.55	277.61	−1.23	1.59	506.33
Average for continental countries	−7.55	923.52	−2.41	−1.43	1549.09

Note: all the averages are weighted by the number of people as of 2020.
Source: own calculation based on data of Eurostat.

Based on data for 2020, we identified four clusters (Table 6). The bottom-right group comprises countries favouring minimum decline in GDP growth rate at the cost of excess deaths (Poland, three other CEE-11 countries and the Netherlands). The upper-left group comprises countries where the effect of their health and macroeconomic policies was a relatively low number of excess deaths, with relatively deep decline in economic growth rate. The bottom-left cluster covers countries that minimized both the number of excess deaths and the decrease in GDP growth rate (all Scandinavian countries, Estonia, Latvia). The upper-right cluster includes those countries where both the number of excess deaths and the GDP growth rate decline were above the median (four Mediterranean countries, four CEE-11 countries and Belgium).

Analysis of the effects of the health and economic policies based on the data on the cumulated growth rate and excess deaths in 2020–2021 made it possible to identify six clusters (Table 7). Poland and almost all CEE countries were in one of the three clusters where the number of excess deaths was higher than the EU-27 median. At the same time, the cumulative growth rate in 2020–2021 in Poland, Croatia, Lithuania, Latvia, Romania, Slovenia and Hungary was positive (bottom-right and middle-right clusters). On the other hand Bulgaria, Czech Republic, and Slovakia, along with Mediterranean countries, were in the upper-right cluster, which, despite a relatively high number of excess deaths, did not achieve positive cumulative GDP growth rate. Consequently, both in Poland and in the other CEE-11 countries, more or less deliberate priority of the state authorities was the condition of the economy, even if it meant rapid increase in excess deaths. Only one country from this group (Estonia) was placed in the bottom-left cluster, where the number of excess deaths per one million people was below the median. Still, the value of this variable in Estonia was over 2726, while in other countries in this cluster it was approximately: 434 for Luxembourg, 641 in Denmark, 821 in Ireland, 1170 in Finland and 2303 in France. One exception was Sweden, which recorded a negative result (– 292). This means that the number of deaths in the analysed period dropped there by 292 in relation to the two-year average from 2010–2019. It suggests a possibility to apply an alternative strategy of dealing with the effects of the pandemic on human health and economy, as proven by the examples of Scandinavia, Ireland, and Luxembourg. In these countries a relatively high cumulative GDP growth rate was achieved at the cost of a comparably small relative number of excess deaths. Finally, the upper-left and middle-left clusters comprise countries representing mostly the continental model of capitalism, as well as Malta and Cyprus, which, as a result of their macroeconomic and health policies, reduced the number of excess deaths below the EU-27 median on the one hand, and on the other observed a very moderate GDP growth rate (Belgium, Cyprus, Malta, Holland) or even its decline (Germany, France and Austria).

Table 6. Division of EU-27 countries into clusters according to data for the year 2020

		Relative number of excess deaths in 2020 in relation to the 2010–2019 average Median value: 1307.32	
		Below the median	Median and above
Economic growth rate (2020 in relation to the 2010–2019 average) Median value: – 6.74 pp	Drop below or equal to the median	Cyprus, France, Malta, Austria, **Slovakia**	Belgium, **Czech Republic**, Greece, **Hungary**, Spain, **Croatia**, Italy, Portugal, **Romania**
	Drop above the median	Denmark, **Estonia**, Germany, **Latvia**, Luxembourg, Finland, Sweden, Ireland	**Bulgaria**, **Lithuania**, **Poland**, **Slovenia**, Holland

Note: CEE-11 countries are in bold print.

Source: self-reported data.

Table 7. Division of EU-27 countries into clusters according to aggregate data for the years 2020–2021

		Relative number of excess deaths in 2020–2021 in relation to the two-year average in the 2010–2019 period Median value: 2762.91	
		Below median	Median and above
Cumulative GDP growth rate in 2020–2021 Median value: 0.82	GDP drop	Germany, Austria, France	**Bulgaria**, **Czech Republic**, Greece, Spain, Italy, Portugal, **Slovakia**
	Growth rate higher than or equal to the median	Belgium, Cyprus, Malta, the Netherlands	**Latvia**
	Growth rate higher than the median	Denmark, Estonia, Ireland, Luxembourg, Finland, Sweden	**Croatia, Lithuania, Hungary, Poland, Romania, Slovenia**

Note: CEE-11 countries are in bold print.

Source: self-reported data.

In the analysis of the results (Tables 6 and 7) attention should be paid to the changes between the year 2020 and 2021. 2020 was a year of complete shock, which made the numbers of excess deaths and economic growth rate entirely dependent on permanent features of long-term state policies and preferences of the societies. These were primarily:

- underinvestment of health care;
- structural features of the labour market (especially low unemployment benefits, forcing people to work despite being ill);
- low level of confidence in governments and preferences for individual wealth, hindering the development of public health care system and lack of acceptance for measures such as lockdown.

The year 2021 brought the possibility to adopt additional measures mitigating negative consequences of the pandemic, such as common COVID-19 vaccination schemes. In some countries vaccination programmes were strongly supported by the governments (up to mandatory vaccination or obstacles in public places for the unvaccinated by using so-called Covid passports), in other they were not. Social trust in vaccination was also lower in more traditional societies, which are more distrustful of scientific research.

The division of the sample into clusters presented in Table 7, compared to the division in Table 6, illustrates changes in the sacrifice strategy during the COVID-19 pandemic in various EU countries. In some of them in the second pandemic year the strategy remained unchanged in relation to 2020, which brought about differentiated economic results. This is the case for all the clusters on the right-hand side of Table 7. Some countries (Croatia, Lithuania, Hungary, Poland, Romania, and Slovenia) were still effecting the sacrifice strategy with positive economic effects (relatively high GDP growth rate). Other had to confront the negative consequences, which were made visible in the two-year period. This was the case for the other CEE-11 countries and Mediterranean countries.

Considering therefore the division of the EU-27 into clusters, based on the data for both the year 2020 and the 2020–2021 period, it should be highlighted that economies from CEE-11 were each time in four different clusters, representing totally different effects of health and economic policies. In our opinion this confirms the hypothesis about internally diversified, patchwork-type model of capitalism, typical for EU Member States from the Central and Eastern Europe [Rapacki, 2019; Rapacki et al., 2019], especially compared to countries representing other models of European capitalism. The presented division into clusters, based on the data for the year 2020 and the two-year pandemic period (2020–2021) shows that Sweden, Denmark, Finland, i.e. countries with the Nordic capitalism model, as well as Italy, Portugal, Greece, and Spain (Mediterranean model) had in place internally consistent, yet mutually diversified (and different from CEE-11 countries) strategies for health and macroeconomic policy.

Let us also highlight differences in the scale of the basic instrument mitigating the negative consequences of the pandemic (number of excess deaths), which was common vaccination. All the countries where the number of excess deaths in the two-year period was below the EU-27 median (except Cyprus and Estonia) had over 70% of their population vaccinated, which, according to experts, means that her immunity is achieved.

On the other hand, CEE-11 countries that were grouped in the right-hand side clusters of Table 7 (with relative number of excess deaths above the median) had less or much less than 70% of their population vaccinated. The Mediterranean countries (Greece, Spain, Portugal, Italy) reached very high rates of vaccination, but their numbers of excess deaths above the median were a consequence of extraordinarily high death rate in 2020 caused by the complete shock of the pandemic outbreak. At the same time, their poor economic performance in the two-year period was probably caused a result of slump in their tourism sector.

Some countries were consistently applying an alternative strategy resulting in low death rate – either scarifying economic growth, probably temporarily (Germany, Austria, France) or without the sacrifice (mostly Scandinavian countries and some countries of the continental Europe). As mentioned before, these good results were conditioned by, apart from the generally well developed health care system, high rate of vaccination in these countries, supported by both state policies and higher social awareness.

CEE-11 countries did not take the opportunity in 2021 to improve their health situation. It leaves open the question about the consequences of this inaction in the autumn of 2022, when the next wave of infections and deaths will come, and the economy will remain strongly affected by high inflation, real threat of recession and war in Ukraine.

Summary

The most important findings from the research presented here may be summarised as follows.

In the first, unanticipated phase (2020) the COVID-19 pandemic caused **obstruction of economic growth trajectories observed hitherto in the EU**. GDP across the EU fell by more than 6%. At the same time, the recession was nearly twice as deep in the economies of the "old" Union as in the CEE-11. In Poland, the recession turned out to be much more moderate than on average in the EU-27 and CEE-11. The same conclusions were brought by the analysis of deviation of GDP growth rate in 2020 from the mid-term trend (2010–2019).

In 2021, **EU countries returned to their economic growth** trajectories. GDP in the entire EU grew by 5.4%; the growth rate in CEE-11 was higher than the average and in the EU-14 it was lower. Poland's growth rate was slightly higher than the average for both CEE-11 and EU-27. In the two years of the pandemic only CEE countries managed to exceed the pre-crisis production volume (by 1.7%). In the entire EU GDP in 2021 was by 1.1% lower than in 2019, while in EU-14 it was lower by 2.1%. The strongest economic upswing after the first pandemic year was observed, among others, in Poland (over 3% GDP growth in two years). At the other end were ten EU countries in which GDP in 2021 was still lower than in 2019.

According to data for the 2020–2021 period, in the conditions of the COVID-19 pandemic with the accompanying recession and economic slowdown, **unemployment in CEE-11 (including Poland) remained low.** This may mean that economic policies there were relatively effective in terms of jobs protection.

The coronavirus shock, on the other hand, entailed a **significantly faster increase in inflation rate**, especially in the second, anticipated phase of the pandemic (2021). This phenomenon extended to encompass countries in both the "old" and "new" EU, with a tendency to accelerate further in 2022.

Comparison of CEE-11 countries with the Western Europe (EU-14) in respect of inflation and unemployment rates exposes two major differences. First, **in the CEE-11** countries in 2020–2021 **the inflation rate was on average higher than in the EU-14**. Second, in both years **unemployment rates in EU-14 countries were higher than in CEE-11.**

The impact of the COVID-19 pandemic on the economies of EU Member States was also made through economic policy effected in 2020 and 2021. In the first year of the pandemic it manifested itself mostly by a **surge in public finance deficit.** In Poland, the deficit was 7.1% of GDP, slightly exceeding the average for CEE-11 and EU-27 as a whole.

The fiscal expansion was also somewhat **supported by the monetary policy**. The support consisted in maintaining negative real interest rates by central banks (and ECB) and active purchase of financial assets on the secondary market (quantitative easing).

Generally speaking, faster growth of inflation in Poland and other EU countries after the coronavirus pandemic was caused by a combination of various factors that can be grouped in two basic categories:

1) **global phenomena** affecting all the EU countries;
2) **factors specific for individual economies**, including Poland.

For the first category, the main causes of inflation growth may be in turn divided yet in two further groups:

a) negative exogenous supply shocks;
b) positive endogenous demand shocks.

Some of the most important sources of negative exogenous supply shocks are:

a) disruptions of supply chains in global production networks of multinational corporations;
b) rise in energy commodity prices in the second half of 2020 and 2021.

The major stimuli of **positive endogenous demand shocks** were the following changes in the national (community) economic policy:

a) rapid increase in public spending and budget deficits in EU Member States in 2020;
b) quantitative easing (purchase of financial assets on the secondary market) effected by central banks.

In Poland, the unprecedented growth of inflation was also induced by:

a) excessively generous policy of social transfers, not balanced by adequate production investments;
b) excessively expansionary monetary policy, inadequate to the changing economic situation;
c) increasing wage-price spiral, which occurred in the conditions of excess demand over supply on the labour market and growing number of bottlenecks in goods production;
d) depreciation of PLN on the foreign exchange market – according to some experts this group of factors could be responsible for almost half of the inflation increase in 2021 and Q1 2022.

The COVID-19 pandemic did not significantly affect unemployment, which in most EU countries (including Poland) remained low in the years 2020 and 2021. However, based on available yet incomplete information, it can be presumed that the low unemployment rate was a "fig leaf" covering structural disturbances of the EU labour markets, aggravated by the pandemic crisis.

The most important **changes on the labour markets** resulting from the COVID-19 were:

1) progressing segmentation of the labour market;
2) common remote work;
3) broader collaboration between the state, employer organisations and trade unions;
4) higher rate of membership in employee organisations.

The fight with the COVID-19 pandemic meant that EU governments have had to **choose between protecting human life and health on the one hand, and maintaining jobs and previous rate of economic activity on the other.** Choice of any of these goals implied a price to be paid for its achieving (e.g. excess deaths as a price for sustaining previous economic growth rate). Also, prioritizing the goal of keeping previous employment in the economic policy entailed an additional cost in the form of increased rate of inflation.

Therefore, in this study we calculated **two measures: economic sacrifice coefficient and health sacrifice coefficient.** The former shows inverse relationship between unemployment rate and inflation rate. The latter shows the relationship between the relative excess number of deaths caused by COVID-19 and the slowdown in economic growth (the depth of recession).

Economic sacrifice coefficient was defined as a quotient of change in inflation rate (in percentage points) and change in unemployment rate defined in a parallel way. Sacrifice (cost) in the form of increased inflation for lower (or maintained) unemployment rate means that the coefficient value is negative. To evaluate comprehensively the effects and costs of policy aimed at maintaining employment rate, it is required to have not only the economic sacrifice coefficient, but also to other elements: direction of the change of inflation rate and direction of the change of unemployment rate.

Analysis of economic sacrifice coefficient referred particularly to the year 2021, when the rate of inflation accelerated in 25 out of 27 EU countries. Depending on the direction of changes of inflation and unemployment rates, **EU-27 countries can be divided into** four clusters with the following sets of features:

a) growing inflation rate and growing unemployment rate,
b) growing inflation rate and falling unemployment rate,
c) falling inflation rate and growing unemployment rate,
d) falling inflation rate and falling unemployment rate.

CEE-11 countries have been categorised in two clusters. The first one, featured by growing inflation rate and falling unemployment rate in 2021, comprised Estonia, Lithuania, Latvia, Romania, Slovenia, and Hungary. The second one, featured by simultaneous growth of inflation and unemployment rate, comprised Bulgaria, Croatia, Czech Republic, Poland, and Slovakia. Correlation coefficient between change in inflation rate and change in unemployment rate in CEE-11 in 2021 was negative (–0.6780) and statistically significant (with significance at 5%). In the entire EU-27 no statistically significant relationship between inflation and unemployment was observed in 2021.

In Poland, the economic sacrifice coefficient was –12.8 in 2020 and 7.8 in 2021. In other words, the unemployment drop by 1 pp recorded in 2020 was connected with increase in inflation rate by 12.8 pp. This means very high cost of jobs protection policy, the highest in the EU. In 2021 Poland observed both growing inflation and unemployment: inflation increased by 7.8 pp per 1 pp of unemployment growth. This may be interpreted as a symptom of poor efficiency of economic policy in terms of both labour market and prices stability.

Our empirical estimates of economic sacrifice coefficient should be interpreted as a combined effect of four different shocks in 2020–2021: **short- and long term shock and supply and demand shock**. This means a simultaneous upward shift of the Phillips curve (and movement along the new curve) and shift toward the left of the vertical, long-term Phillips curve, which reflects **faster inflation growth in the situation of decreased potential production and rising natural unemployment rate**.

Health (Covid) sacrifice coefficients were calculated separately for the year 2020 and the 2020–2021 period. In both cases, they turned out to be the lowest in countries embodying the Nordic model of capitalism (Denmark, Finland, and Sweden). Throughout the pandemic period the coefficients were the worst in countries representing the Mediterranean model of capitalism, and in CEE-11 countries. The results in Poland were worse than the EU-27 average, but better than the CEE-11 average.

Since it is difficult to interpret unequivocally the health sacrifice coefficient with various directions of changes in GDP growth and rate, we applied another measure enabling evaluation of differentiation and efficiency of economic and health policies in the EU: **analysis of distribution of the characteristics in relation to the median**. Based on the two criteria: changes in GDP growth and rate (and their direction) and relative number of excess deaths in relation to the EU-27 median, we identified among the Member States **four clusters (2020)** and **six clusters (2020–2021)**, respectively.

The best performers in terms of their response to the COVID-19 pandemic – both in 2020 and in the entire 2020–2021 period – were in the first place the **Scandinavian countries**, as well as Ireland, Luxembourg, and Estonia. There, GDP growth in

2020–2021 was higher than the EU-27 median (and the recession in 2020 was milder), and the relative number of excess deaths due to the virus was the lowest.

At the other end of the spectrum there were the **Mediterranean and three CEE states (Bulgaria, the Czech Republic and Slovakia)**. These countries showed the worst possible mix of outcomes: a cumulative GDP decline after two years of the pandemic and a relative number of excess deaths well above the median for the EU-27. This is equivalent to saying that attempts to sustain economic growth there proved ineffective and, worse, came at a very high cost.

Poland, along with five other CEE-11 countries, was found in the cluster where economic growth in 2020–2021 was faster than the EU-27 median (and the recession in 2020 – shallower), but the cost of achieving this goal (the relative number of excess deaths) turned out to be above average.

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CENTRAL AND EASTERN EUROPEAN ECONOMIES DURING AND AFTER COVID-19 CRISIS

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Abstract

The study analyses changes in nine economies of the Central and Eastern Europe (CEE): Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, and Slovakia, resulting from the outbreak and then gradual regression of the COVID-19 pandemic, with particular focus on transformation observed in the processing industry, construction, and trade. Analyses show that the COVID-19 crisis was an unprecedented shock for the entire region. All the CEE countries experienced profound changes in their economic activity. The pandemic-induced crisis was violent, yet short. Loose fiscal and monetary policy that was supposed to mitigate negative effects of the economic downturn, contributed to sharp growth of inflation rate. Already in the second half of 2021 increase in consumer prices pushed down consumer sentiment, and producers found rising raw material prices, combined with intensifying supply problems, to be the major barriers for their business activities.

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The SARS-CoV-2 pandemic and measures taken to counteract it had an enormous effect on the global economy, including the region of Central and Eastern Europe (CEE). The pandemic hit individual countries with different force because of numerous factors: structures of their economies, their condition before the crisis, condition of their healthcare, social and economic support instruments introduced, efficiency of measures of fight against the pandemic, etc. Economies had to face up to new challenges that emerged during the pandemic: hurdles in procurement of raw materials and goods, intensifying price growth, shortage of labour force and many other. This in turn led to various supply and demand restrictions, threatening the recovery of economic activity after the pandemic is over. The COVID-19 crisis accelerated changes both in the contraction and the expansion phase of the business cycle. Just as introduction of restrictions caused almost immediate standstill in various sectors, lifting them caused quick response of enterprises and consumers willing to resume their previous patterns of production and consumption. All the market participants were quickly learning how to act in the unusual conditions. The pandemic is not yet over, though. At the current stage we can analyse short-term effects of the crisis, but it is still too early to assess its impact in the long term. In the meantime other risks have arisen, especially for the CEE region, such as those connected with the war in Ukraine.

This article analyses the situation in nine CEE economies: Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, and Slovakia, with particular consideration for the economic climate in processing industry, construction and trade. The analysis is based on quantitative variables describing the macroeconomic situation of individual economies: GDP, investments, private consumption, retail sales, sold production of processing industry and construction, as well as economic indicators developed on the basis of research data obtained with business situation test method. They reflect opinions and sentiment of economy actors.

The analysis of economic situation focuses on evaluation of cyclical fluctuations, defined as deviations from the main trend. Reference variables for fluctuations in the region's economy will be relevant macroeconomic indicators describing the situation in the European Union (EU) as a whole (EU-27). Comprehensive documentation of analysis results is available on the website of the Institute of Economic Development (IEC) of SGH and in the materials provided by the Forum.

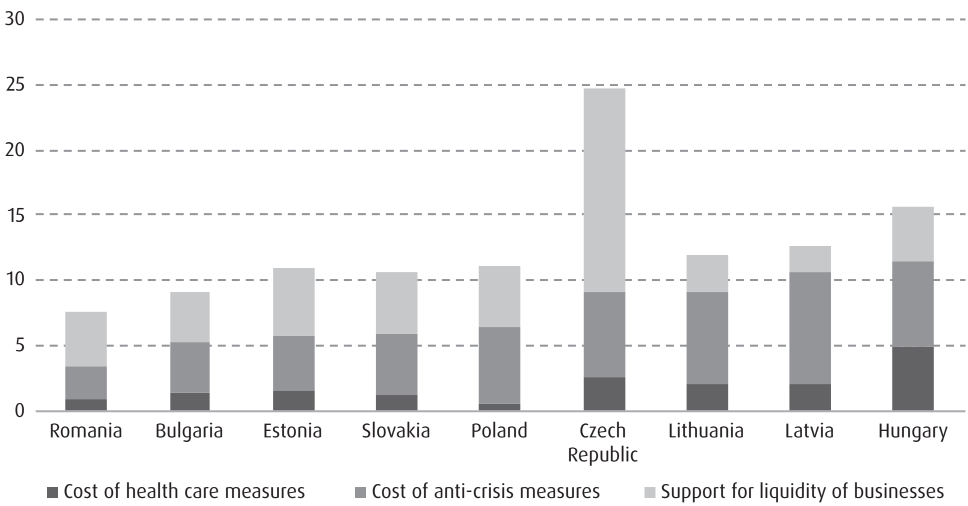
Government support for the economy during the pandemic

The economic crisis caused by the COVID-19 pandemic compelled EU states to adopt policy aimed at maintaining production capacity across the entire economy. That is because bankruptcies would cause a sharp rise in unemployment, slump in real and potential GDP, and serious social problems. To prevent it, governments of EU countries effected fiscal and monetary expansion on an unprecedented scale.

Measures to counter the crisis in Poland, implemented under the slogan of "anti-crisis shield" focused mostly on financial support for enterprises during epidemic restrictions, ensuring social security for those particularly affected by the crisis, and spurring the economy in line with Keynesianism, i.e. by stimulating aggregate demand with fiscal and monetary tools. The main tool of this strategy were so-called financial shields financed from bonds. In 2020, as a part of the shields companies received PLN 61 billion of subsidies from Polish Development Fund (PDF), and in 2021 they were granted further PLN 8.8 billion. The financing was non-repayable in 75% or 100% percent. Another support instrument were subsidies for employee salaries for businesses affected by restrictions. They amounted to 50–90% of minimum wage and were paid out by the Polish Social Insurance Institution (ZUS) in 2020–2021. ZUS also effected another support measure, namely exemption from social insurance contributions for the second quarter of 2020, and, for some sectors, for the period from December 2020 to April 2021. State financial support included also low-interest loans of PLN 5000 for businesses in 2020 (waived for those enterprises that would retain all their employees through the pandemic) and non-repayable subsidies of PLN 5000 for some sectors in 2021. Moreover, Social Insurance Institution paid out downtime allowance of 50% or 80% of minimum wage per each worker in sectors covered by pandemic restrictions. State support for businesses included also: subsidies for the railway company PKP PLK, airports and seaports, exemption from farmers' social insurance contributions, support for the Industry Development Agency, payments from the Tourist Refund Fund, and other.

Social support for groups most affected by the COVID-19 pandemic covered: financing for nursing homes, sick pay, care allowances for parents staying at home with their children and pay supplements for medical staff. Additionally, households were offered financing for holiday trips by Polish Tourist Vouchers and teachers received allowances for purchases of IT equipment used for remote teaching.

Figure 1. State expenses connected with COVID-19 pandemic in CEE (% GDP)



Source: self-reported data based on IMF [2021].

International Monetary Fund [IMF, 2021] estimates that Poland is in the middle of CEE ranking of the volume of money assigned to counter the COVID-19 pandemic (Figure 1). Additional expenses for healthcare in Poland were the lowest in the entire region (0.6% of GDP compared to the average 1.9% of GDP in CEE), and the volume of expenses for anti-crisis measures in the economy slightly exceeded the CEE average (5.8% of GDP compared to the average of 5.6% of GDP). Types of support for businesses and social support did not differ substantially from that provided in other countries (Table 1). The share of direct grants and subsidies for businesses was relatively high (financial shields of the Polish Development Fund and PLN 5000 subsidies), and reached about 2.2% of GDP (similarly to Latvia and Hungary). However, Poland had a relatively low volume of reliefs and tax exemptions; in other countries these solutions were more significant.

General economic situation

The COVID-19 crisis hit the region's economy, which was already in slowdown. The peak of economic activity in EU-27, just as in most CEE countries, occurred more or less in mid-2018 [Adamowicz et al., 2020]. The pandemic made the downturn even more rapid. However, it did not last long. Already in the second quarter of 2020 the downturn was stopped, and in next months it was evident that the economy was recovering to reach pre-crisis level. In 2021 CEE economies, including Polish one, returned to the growth path. Nevertheless, symptoms of yet another economic slowdown recorded in the second half of 2021 show that the post-crisis upswing was also temporary.

Changes of the economic situation in the region were to a large extent synchronised. This resulted mostly from the fact that administrative restrictions imposed on economic activity were in most countries adopted simultaneously. The efforts of individual governments to rebuild their economies were also taken simultaneously. The main feature that differentiated the course of the Covid crisis was the reaction of the private sector.

The biggest drops in the major macroeconomic variable, GDP, took place in Q2 2020. In the EU, the total decrease was 13.7% y/y (seasonally adjusted). Broken down into individual countries of the region it was as follows: 13% in Hungary, 10.9% in Czech Republic, 10.1% in Slovakia, 8.8% in Romania, 8.7% in Latvia, 7.9% in Bulgaria, 7.8% in Poland, 6.0% in Estonia, and 3.6% in Lithuania. From Q3 2020 until the end of 2021 GDP was growing. The pace of growth, however, was diversified in time and among countries. Due to so-called low base effect, the highest GDP was recorded in Q1 2021, reaching 8.6% y/y in Lithuania and 17.6% in Hungary. In next quarters of 2021 the growth rate was gradually falling across the CEE region. By the end of the year the highest real GDP growth rate (8.8%) was recorded in Estonia, and the lowest (1.2%) in Slovakia.

Table 1. Types and volume of financial support in CEE (estimates)

Country	Support for the economy (% GDP)	Major support instruments	Cost of support instrument in 2020 (% GDP)
Romania	2.5	subsidies for enterprises affected by the pandemic	0.81
		pay supplements (75% of salary) for employees in sectors affected by the pandemic	0.49
		increase in expenses for unemployment benefits	0.43
		pay supplements for employees staying at home with children during pandemic	0.08
		temporary exemptions from CIT for entrepreneurs	0.08
Bulgaria	3.9	pension supplement and increase in minimum wage	1.37
		pay supplements (60% of salary) for employees in sectors affected by the pandemic	0.95
		increase in social expenses and unemployment benefits	0.58
		reduction of VAT on catering, sports, and tourist services and for children products	0.29
		active labour market policy	0.09
Estonia	4.2	expenses of Kredex and Enterprise (EAS) for development of housing, roads, and shipbuilding	1.44
		temporary reliefs and tax exemptions	1.18
		pay supplements for employees in sectors affected by the pandemic	0.93
		reduction of excise duty on fuel	0.29
Slovakia	4.7	social works programme for those who lost job due to pandemic	1.0
		increased expenses for sick pay and care allowances	0.8
		subsidies for enterprises affected by the pandemic	0.8
		wage growth in the public sector	0.6
		tax exemptions for enterprises recording sales drop by at least 40%	0.5
Poland	5.8	subsidies for enterprises from PDF financial shields for large and small enterprises	2.2
		pay supplements (50% of salary) for employees in sectors affected by the pandemic	0.9
		temporary exemption from social insurance contribution	0.7
		non-repayable loan (subsidy in 2021) of PLN 5000 for companies that retain their staff	0.6
		increased social expenses (solidarity supplement, Polish Tourist Voucher, sick pay, support for people with disabilities and artists)	0.4
		downtime allowances for enterprises from sectors affected by restrictions	0.3

Country	Support for the economy (% GDP)	Major support instruments	Cost of support instrument in 2020 (% GDP)
Czech Republic	6.6	tax reform of 2021 (big reductions of VAT and direct taxes)	2.49
		one-off allowance for the self-employed, small entrepreneurs and those on temporary contracts	0.96
		pay supplements for employees in certain sectors	0.87
		subsidies for enterprises in sectors particularly affected by the pandemic	0.62
		temporary exemption from social insurance contribution	0.49
		one-off pension rise	0.27
		temporary exemption from real-estate tax	0.24
Lithuania	7.1	pay supplements for employees in sectors affected by the pandemic and the self-employed	1.61
		unemployment benefits and benefits for families affected by a job loss by a parent, pension supplements	1.47
		subsidies for enterprises to retain staff and for hiring the unemployed	1.34
		temporary tax exemptions for businesses in sectors affected by the pandemic	1.17
		programme of investments in local roads and State Investment Programme	0.89
		subsidies for enterprises and farmers	0.56
Latvia	8.6	subsidies for companies in the aviation sector	1.3
		subsidies for enterprises and farmers	1.1
		one-off tax relief in 2021 for families with at least one child and pensioners	1.0
		road and bridge investment scheme	0.7
		exemptions from PIT and social insurance contributions for businesses and people in sectors affected by the pandemic, faster VAT returns	0.5
Hungary	6.6	expenses from newly established support programmes (Anti-pandemic Protection Fund and Economy Protection Fund) to subsidise enterprises, interest rates paid by businesses and public investments	4.14
		pay supplements (50% of salary) for employees in sectors affected by the pandemic	0.37
		reduction of tax wedge of employees from 17.5% to 15.5%	0.98
		tax exemptions for businesses in sectors affected by the pandemic	0.40
		temporary rise of bank tax and reduction of political party subventions in order to finance economy recovery	−0.12
		reliefs for families for children for house renovations	0.26
		pension supplement equal to weekly pension paid from 2021 to 2024	0.15

Source: self-reported data based on data of: IMF [2021]; Mora, Galuščák [2022]; Konat, Olejnik [2022] and Convergence Programmes and Stability programmes listed in the references.

As for qualitative variables, an equivalent of GDP is economic sentiment indicator – ESI. In all the analysed CEE countries, just as in the rest of EU-27, at the beginning of

Q2 2020 a significant drop in ESI was recorded – the biggest in Slovakia (by 38.9 points, which is 3.7-fold of standard deviation) and the smallest in Latvia (by 18.1 points, 1.6-fold of standard deviation). At the turn of 2021, both in EU-27 and in most CEE countries the value of ESI fell again, which probably reflected growing uncertainty and pessimism of the economy actors.

The COVID-19 crisis was the shortest crisis since the system transformation in CEE – it lasted only one quarter. However, its impact was stronger (in most countries) than of any other previous slumps. The COVID-19 pandemic accelerated economic downturn, which has been slowly proceeding already since 2018. The research of SGH Institute Economic Development [Adamowicz et al., 2022] shows that at least in Poland the changing epidemic situation exacerbated the economic downturn, which would have happened even without SARS-CoV-2. But the economy picked up quickly and entered the phase of recovery. Still, risks for continued growth have emerged recently, connected mostly with yet unknown time of potential end of the pandemic and its further course. Therefore, CEE countries started the year 2022 with large uncertainty, declining rate of GDP growth and falling sentiment. New phenomena occurred apart from recent obstacles, such as supply chain disruptions and limited availability of raw materials and goods. These new shocks are the rampant inflation and tense geopolitical situation connected with the outbreak of war in Ukraine.

Private consumption during the COVID-19 pandemic

Economic crisis caused by the COVID-19 pandemic affected the situation of households and their expenses in many ways. First, as a result of temporary suspension of some service sectors (restaurants, hotels, entities providing leisure services, hairdressers, beauticians, etc.) and retail shops, spending on consumption goods and services was reduced. The decline was only partially compensated by internet shopping. Second, the crisis contributed to the decrease in employment rate, working time and pay, which caused a negative income effect, thereby lowering total demand. Third, in the initial phase of the crisis, enormous uncertainty among the society and fears of loss of job, health, income decline, and other phenomena could be observed, which translated into lower consumer sentiment. Household condition indicator (CSI) in April 2020 fell (in relation to February) by: 12.4 points in Bulgaria, 14.9 points in Czech Republic, 15.7 points in Estonia, 17.4 in Lithuania, 18.6 in Romania, 20.7 points in Slovakia, 22.3 points in Latvia, 23 in Poland and 26.2 points in Hungary (in total by 16.2 in EU-27), i.e. from 1.6-fold standard deviation in Hungary to 3-fold standard deviation in Poland. Social emotions were extraordinarily high, which inclined households to increase their precautionary savings. Fourth, a part of consumption demand was redirected to substitute products and services (takeaway meals, food with long expiration dates and other similar goods) and goods satisfying intensified needs directly and indirectly induced by the epidemic (sanitary and hygiene products, medical equipment, computer, and telecommunications equipment, etc.).

The overlapping supply and demand effects working in different directions and having different structure, combined with consumer pessimism, reduced the volume of consumption already in Q1 2020. The contraction phase of the cycle, however, began long before the recession. The "Covid" crisis coincided with a cyclical decline in consumption, which in CEE started at least at the beginning of 2019. A severe slump was recorded in Q2 2020. The rate of consumption fell in all the EU-27 countries – in Q1 and Q2 2020 it was 15.6% (seasonally adjusted). The deepest decline was recorded in Latvia (by almost 18%), and the smallest in Slovakia (by 4.6%). In Poland real consumption decreased by 11.2%, in Hungary by 8.2%, in Czech Republic by 10.8%, in Estonia by 8.7%, in Lithuania by 9.9%, in Bulgaria by 5.1% and in Romania by 13.9%.

It started to pick up already in Q3 2020 and the recovery was proceeding along with subsequent waves of the pandemic. Not all the countries saw the consumption come back to the pre-pandemic level by the end of 2021. In Czech Republic in Q4 2021, compared to Q4 2019, consumption rate was lower by 1.2% and in Latvia by 0.2%. The rest of the region recorded an increase in real consumption (the biggest in Bulgaria – by 8.4%).

The years 2020–2021 were extraordinary in respect of economic sentiment. The pandemic caused surge in uncertainty, which was nevertheless only temporary. Increase in social tension and deterioration of consumer sentiment generally were not as strong as during the global financial crisis in 2008–2010 or the euro zone crisis in 2012–2013. This means that a significant factor in the consumer behaviour during the COVID-19 crisis was overreaction. The overreaction, fed by strong, negative media coverage, was a result of the pandemic precedence as a source of shock (or lack of similar experience in the contemporary economy), incapacity of authorities or other factors. During next waves of the pandemic there was no deterioration of social sentiment as strong as during the second quarter of 2020. Households got used to the pandemic reality. It should be noted, however, that while the current consumption rate in most CEE countries is already higher than before the COVID-19 crisis, consumer sentiment is still falling (CSI in January 2022 was in most countries lower than in January 2020 – the decrease was from 6.1 points in Hungary to 16.1 points in Czech Republic; only Bulgaria recorded a 3.3-point growth in that period), pushed down partly by inflation expectations.

Business investments

Changing economic conditions and consumer expectations usually trigger quick and strong investment response [Radzikowski, 2022]. In the last quarter of 2019 investments were rising (gross expenditure for fixed assets in constant prices, y/y, seasonally adjusted) in all the countries of the region. In most cases their growth rate was worse than in the previous quarter, though. Outbreak of the COVID-19 pandemic caused a big decrease in investments. In Slovakia in Q1 2020 it was 7.9%, in Czech Republic 4.7%, in Hungary 4.1%, in Estonia 3.7% and in Bulgaria 1.1%. Investments in that time were rising in Lithuania (by 1.5%), Poland (by 2.9%), Latvia (by 5.2%) and Romania (by 8.1%) and in the European Union as a whole (5.6%). The second quarter of 2020, however, brought substantial drops in almost all CEE countries: in Slovakia investments dropped by 14.9%, in Lithuania by 13.2%, in Estonia by 11.9%, in Poland by 10.5%, in Hungary by 9.7%, in Czech Republic by 6.3% and in Latvia by 4.0%. Only two countries did not record lower investment rate; in Bulgaria the growth was 0.0% and in Romania it was 0.9%. By comparison, in the EU as a whole investments fell by 17.9% and the drop was the biggest not only during the entire pandemic, but also in the history of EU – it was even bigger than the one recorded during the global financial crisis (in Q2 2009 investments in EU fell by 12.4%).

In some countries of the CEE region the biggest drops in investment rate occurred in the following quarters – Q3 2020 in Hungary (by 12.5%), in Q4 2020 in Slovakia (by 15%), in Poland (by 13.7%) and Czech Republic (by 10.1%), and in Q4 2021 in Estonia (by 38.3%), Bulgaria (by 13%) and Romania (by 5.9%; for Bulgaria and Romania only preliminary data have been provided). The drops in most cases were not as big as during the 2008–2010 (then they reached 29–44.5% in Slovakia, Bulgaria, Romania, and Baltic states[1], and in Hungary, Czech Republic, and Poland respectively: 11.5%, 10.8% and 5.7%).

At the turn of 2020 in the countries of Visegrad Group, in Lithuania and in the EU as a whole investment rates bounced back from the lowest levels recorded in the COVID-19 crisis. Currently, however, they are still much lower than before the outbreak of the pandemic. Data for the remaining countries for Q4 2021 do not show any recovery yet.

1 Bigger changes in the investment rate in Baltic states (compared to other CEE countries) may be explained by the sizes of their economies.

Economic situation in the processing industry

Downturn in the processing industry in CEE began long before the COVID-19 pandemic outbreak, in autumn 2018. In most countries symptoms of economic contraction were visible already at least a year earlier. Only in Poland and in Hungary the leading economic indicator in the processing industry, Industrial Confidence Index (ICI), reached the highest level later, in July 2018. After several months of mild decline – except Romania, where the fall trend was stronger than elsewhere – in March 2020, in reaction to the introduction of sanitary regime in the economy, the value of sold production of the processing industry slumped in almost all countries (except Lithuania and Latvia), with the biggest decrease by almost one fourth in Slovakia (y/y, seasonally adjusted). The processing industry bottomed out in April: the fall in the production volume in individual CEE countries was enormous – from 10.1% in Lithuania to 47.6% in Slovakia (27.5% in Poland). Except for the Baltic states, the sales value fell below 2015 annual average, i.e. by: 7.5% in Bulgaria, 8.8% in Poland, 25.2% in Czech Republic, 28.5% in Hungary, 31.4% in Romania and 38% in Slovakia. These were the biggest annual drops in the production value of the processing industry after the economic transformation in these countries. There was some improvement in May, although the annual growth was still negative. In next months, the processing industry was gradually making up for the losses. In Latvia and Poland production volume increased y/y already in July; while in the other countries it did so later (in Bulgaria the latest – in March 2021). In Lithuania, the value of sold production exceeded that of February already in August 2021, in Hungary – in September, in Czech Republic, Latvia and Poland – in October, in Bulgaria, Romania and Slovakia – in Q2 2021. Estonia still has not recovered from losses from before the pandemic. The COVID-19 crisis in the processing industry in CEE was therefore, generally speaking, deep and short-term.

In next months, the economy of the region was feeling the consequences of the crisis, mostly supply chain disruptions caused by temporary downtime or reduction of production and hurdles in international flow of goods, as well as uncertainty about future economic conditions, intensified by subsequent waves of the pandemic. This coincided with the rise in energy prices on the global market, which pushed up the costs of industrial production. The second quarter of 2021 saw signs of economic downturn in the processing industry. In all the CEE countries, except Estonia, the economic climate indicator was the highest since the outbreak of COVID-19 pandemic, which was also evidence of limited opportunities for further increase in industrial production volume. Different CEE countries followed different development paths to recover the pre-crisis volume of production. In Bulgaria, Estonia, Latvia, Poland,

and Slovakia production growth followed the trend at a much slower rate than during the recovery in mid-2020. In Lithuania, for all the year 2021 sold production of the processing industry was growing fast, to reach the real growth rate 10-fold higher than the long-term one. In Hungary, the processing industry was stagnant, without any sings of permanent improvement. In Czech Republic and Romania the decline trend from before the COVID-19 crisis continued. Against this background the turn of 2021 saw an unusual spike in the volume of sold production of the processing industry. According to research on the economic situation conducted before the outbreak of war in Ukraine, the growth is temporary. In all the countries after a short economic upturn in 2021, a decline in producer sentiment could be observed, which in some of them (Bulgaria, Czech Republic, Lithuania, Latvia, and Slovakia) has already translated into lower volume of industrial production. Further decline is expected because of the war in Ukraine and economic sanctions imposed on Russia and Belarus, which will trigger the next wave of supply and demand turmoil in the region's economy.

Generally, despite concurrence of multiple adverse factors, the processing industry has managed to overcome the slump induced by the COVID-19 pandemic, its consequences and further hurdles. In Lithuania and Poland the value of sold production index (2015 = 100, seasonally adjusted) in February 2022 was higher than two years before, or just before the crisis, by, respectively: 36.9 and 26.3 points. Bulgaria, Hungary, and Latvia also recorded growth, yet much smaller, by, respectively: 7.1, 7.8 and 8.8 points. In Romania, Czech Republic, and Estonia the volume of production fell, but the decrease was insignificant, by, respectively: 0.7, 2.2 and 5.8 points. In Slovakia, no changes have been reported so far.

Economic situation in the construction industry

Although the administrative restrictions have not affected the construction industry directly, the COVID-19 pandemic has also made its mark on this sector, mostly by disruption in construction material supplies and pushing down the supply of workforce (due to more people taking sick leaves and reduced international flow of workers). Additionally, the pandemic-induced economic crisis depressed economic sentiments. Evaluation of economic situation in the construction industry in Q2 2020 was strongly negative, close to the ones recorded in 2001–2002 (dotcom bubble crash), 2008–2009 (great recession) and 2012–2013 (euro zone debt crisis). Construction Confidence Indicator (CCI, seasonally adjusted) in April 2020 fell by 41 points in Slovakia, 36.3 points in Romania, 34.8 points in Bulgaria, 33 points in Estonia, 28.4 points in Poland, 17.1 points in Lithuania, 14.5 points in Latvia, 9.5 points in Hungary and 8.5 points in Czech Republic (by comparison, in EU-27 CCI fell by 16.4 points). In Estonia, Latvia, Poland, and Slovakia the economic situation of the construction industry worsened more than ever before. Let us note that in the Visegrad Group states and Baltic states the indicator started to drop earlier, at least by the end of 2018. In Q1 2020 the decline trend was stopped and forecasts for Q2 2020 were optimistic. The pandemic and efforts to combat it turned out to be a strongly negative shock. As a result, the value of sold production in construction decreased in real terms in April 2020 by 13.5% in Slovakia and by 11.2% in Bulgaria (y/y, seasonally adjusted). In Poland, Czech Republic, and Hungary the drop was smaller: 1.8%, 1.9% and 2.4% y/y, respectively. Only Romania recorded a growth (by 9.0%). In the Baltic states sales drop in Q2 2020 was[2]: 0.9% in Latvia, 8.0% in Lithuania, and 8.5% in Estonia. Importantly, a decline in sales of construction services in the CEE countries was much smaller than in EU-27 as a whole, where it reached 24.6% y/y.

After the difficult second quarter of 2020 and protracted problems with financial liquidity, in the third quarter of 2020 the economic climate in construction started to improve gradually. The upturn was observed in all countries, although it varied in strength and was less intensive than in the processing industry. The slow pace of recovery has probably intensified difficulties reported by construction businesses in the research: increasingly onerous tax burden and unstable legal regulations, falling demand and, most of all, rapid growth of construction material prices, which in the following year were the main barrier for the sector (in Q4 2021 three of four construction firms interviewed found the growth of prices of materials to be the main obstacle for running their business, which was a result twice higher than the year before). In the first quarter of 2021, despite the winter season, which for the construction sector means downtime in business, construction firms were slightly optimistic, probably due to some improvement in the prospects of controlling the pandemic connected with mass vaccinations against COVID-19. In the following months, especially May and June, the economic climate was improving. Nevertheless, by the end of the year CCI in Poland was lower than two years earlier by 5.4 points, in Slovakia by 5.7 points, in Czech Republic by 4.4 points, in Hungary by 4.2 points, in Latvia by 4.4 points, in Romania by 1.4 and in Bulgaria by 12.4 points. Only in Estonia and Lithuania the value of the index rose between December 2019 and December 2021 by 35.8 and 5.6 points, respectively (in EU-27 by 3.8 points).

The effect of the pandemic on the volume of construction output in CEE was diversified. In some countries (Czech Republic, Latvia, Slovakia) construction production did not reach the pre-pandemic level by 2021. Their value of construction production

2 Since monthly data are not available, quarterly figures are provided.

index (2015 = 100, seasonally adjusted) was in the fourth quarter lower than two years earlier, by, respectively: 4.0, 11.4 and 7.7 points. In Bulgaria, Estonia, Lithuania, and Poland it restored its pre-crisis level or was slightly higher, by not more than 5 points. In Romania and Hungary it grew as much as by 16 and 20.2 points, respectively.

Economic situation in trade

The COVID-19 crisis, especially temporary closure of sales outlets, caused a sharp and profound economic breakdown in trade and increased pessimism among entrepreneurs. This in turn aggravated both general and financial situation of trade enterprises, reduced the volume of purchases from domestic and foreign suppliers, as well as inventory.

In the Visegrad Group states the economic climate in trade worsened already in 2018–2019. In the other countries of the region for some years before the pandemic the economic climate in trade had not been changing much. In the first quarter of 2020 Poland still recorded a positive value of confidence indicator (at 0.8 points), but in the following quarter the situation of trade businesses changed dramatically. In the second quarter of 2020 the index value decreased in relation to the first quarter by 29.6 points, thereby falling to the lowest level since 1993 (– 28.8 points). Retail sales fell in real terms by 5.6% in March and by further 11.4% in April. Similar fluctuations were recorded also in the EU countries. In April 2020, the value of Retail Consumer Indicator (RCI) in EU-27 hit a low, the deepest decline in the Community's history since 1995 (– 29.1 points, seasonally adjusted). Compared to February, the decrease was in total 30.4 points. Broken down into individual countries of CEE it was: 48.9 points in Estonia, 41.2 points in Romania, 33.6 points in Bulgaria, 31.5 points in Latvia, 30 points in Lithuania, 29.3 points in Slovakia, 27.8 points in Hungary and 19.7 points in Czech Republic. At the same time retail sales (in constant prices, seasonally adjusted) dropped by 10.6% in Czech Republic, 12.3% in Latvia, 15.4% in Hungary, 15.5% in Estonia, 15.8% in Poland, 17.2% in Lithuania, 18.4% in Bulgaria and 24.6% in Romania (by comparison in EU-27 retail sales fell by 18.8%).

More optimism and improvement of economic situation in all CEE countries occurred in the third quarter of 2020. In Poland RCI in that time grew by 24 points, although it remained negative (– 4.8 points). The optimism did not last long, though. In the fourth quarter of 2020 the economic situation in trade deteriorated again. RCI fell by 4.0 points and by the end of 2020 it was at –8.8 points. In the EU-27 and CEE countries the situation was similar. After the record decline in the second quarter of 2020 optimism began to gradually recover in the following months. RCI in EU-27 grew to –7.1 points in September 2020, by the end of the year it fell again, this time to –12 points, which was by 17.1 points higher than at the trough in April. In the CEE countries the increase in RCI between April and December 2020 was from 5.5 points in Bulgaria to 39.8 points in Estonia, while increase in the retail sales index was from 12.5 points in Bulgaria to 39.2 points in Romania (with 20.9 in EU-27).

In the first half of 2021 sentiments in trade improved significantly, and in some countries (Czech Republic, Estonia, Lithuania, Latvia, Hungary, Poland, and EU-27) they returned to the pre-crisis level. Nevertheless, sharp inflation growth in the following months blocked further improvement. In all the CEE countries, except Czech Republic and Estonia, a drop in RCI was recorded in the third quarter of 2021. Although in most of them RCI rates rose again in the fourth quarter, the improvement was not strong enough to compensate for previous decrease. The worse sentiment in trade translated into lower real retail sales, although to a much smaller extent than previously.

Generally, after two years after the pandemic outbreak the situation in trade in most CEE countries is not better than before the COVID-19 crisis. Only in Estonia and Hungary the economic climate in trade has improved. In February 2022 RCI rates in these countries were higher in February 2020 by 2.5 and 0.4 points, respectively. In the other countries of the region RCI decreased by 13 points in Romania, 6.2 points in Lithuania, 5.6 points in Bulgaria, 3.8 points in Czech Republic, 3.2 points in Slovakia, 0.8 in Latvia and 0.2 points in Poland. Unlike in production industry, trade is still in the phase of post-crisis recovery, which in the last months has evidently slowed down, even despite less burdensome barriers and restrictions for trade business. Research on economic climate shows smaller significance of costs of employment, market competition and insufficient demand as factors hindering the development of trade.

In December 2021 in most CEE countries retail sales (2015 index = 100, seasonally adjusted) was more or less at the same rate as two years earlier (+/–5.0 points). In Estonia, Lithuania, Poland, and Romania a growth of 16.9–22.4 points was recorded in this respect.

Summary

The analysis of changes in the economic climate shows that the COVID-19 crisis was an unprecedented event for the entire CEE. All the countries of this region experienced profound and rapid changes in their economic activities as a result of the pandemic. They were reflected by falling major indicators describing economic performance: GDP, sold production of industry and construction, retail sales, consumption, and investments. Even deeper decline was recorded for qualitative variables obtained from research on economic climate and indicators reflecting the sentiment of economic entities. Most dramatic changes resulting from restrictions on business could be observed in Q2 2020. However, it rebounded very quickly, accompanied by attempts to restore economic activities. First, opportunities were opened to shift business activities from traditional conditions to virtual space. That is why the sectors that could take advantage of this solution coped best with the pandemic. Also, attempts to adjust to the changing reality accelerated technology transformation in areas giving hope for quick economic recovery after the pandemic. At the same time, previous relation networks fell apart and problems emerged with availability of not only raw materials and goods, but also skilled labour force. These changes brought adverse effects both for supply and the demand side. Loose fiscal and monetary policy that was supposed to mitigate negative effects contributed to sharp growth of inflation rate. Already in the second half of 2021 increase in consumer prices pushed down consumer sentiment, and producers found rising raw material prices, combined with intensifying supply problems, to be the major barriers for their business activities.

The pandemic-induced crisis was violent, yet short. Common efforts of all the market participants made it possible to overcome it. However, other threats emerged, as a result of not only the growing spiral of inflation, but mostly geopolitical changes. For the CEE it is a time of further difficult challenges.

ATTACHMENT

Enclosure 1. Variable description

The analysis covered major quantitative macroeconomic indicators:

- GDP, constant prices 2015 = 100, Q1 1995-Q4 2021;
- consumption of households and *non-profit* organisations providing services for households (CONS), constant prices 2015 = 100, Q1 1995-Q4 2021;
- investments (INV), constant prices 2015 = 100, Q1 1995-Q4 2021;
- sold production of the processing industry (IP), constant prices 2015 = 100, January 2000–December 2021;
- sold production of the building and assembly industry (BLD), constant prices 2015 = 100, January 2000–November 2021, for Estonia, Lithuania and Latvia: Q1 2000-Q4 2021;
- trade retail sales (TRD), constant prices 2015 = 100, January 2000–December 2021;
- and qualitative data from research carried out using business situation test method:
- economic sentiment indicator (ESI), January 1996–January 2022;
- consumer sentiment index (CSI), May 2001–January 2022, without Romania because of lack of data;
- industrial confidence index (ICI), January 2000–January 2022;
- construction confidence index (CCI), January 1998–January 2022;
- retail trade confidence index (RCI), January 2000–January 2022

The confidence indicator series for processing industry in Poland was taken from research on economic climate conducted by the SGH Institute of Economic Development.[3] The other data are based on the data of Eurostat (https://ec.europa.eu/eurostat/data/database) in the form of seasonally adjusted (SA) and seasonally and calendar adjusted (SCA) series. Cyclical components (C) were separated using Christiano – Fitzgerald filter. Data of the SGH Institute of Economic Development have been deseasonalized before detrending using the X-13ARIMA-SEATS method.

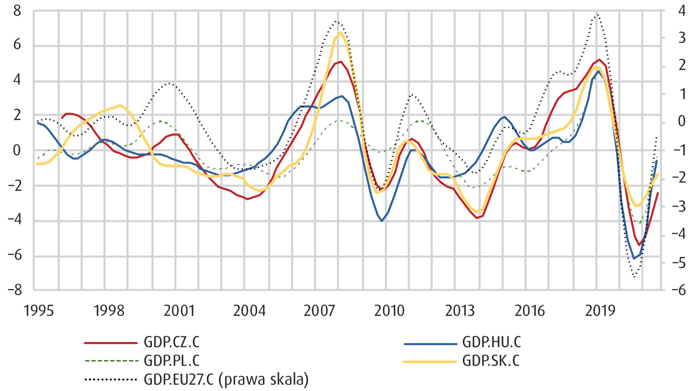
On the charts in Enclosure 2 adjusted series and their cyclical components are described in the following manner: [code_of the indicator]. [code_of the country]. [code_of transformation_of series]. For example GDP.BG.C means cyclical component of single-based index GDP in Bulgaria in (average) prices from 2015, ICI.PL.C means cyclical component of processing industry confidence (based on the research of SGH IED)

3 More about economic climate research by the SGH Institute of Economic Development on http://kolegia.sgh.waw.pl/pl/KAE/struktura/IRG/ koniunktura/ Strony/default.aspx (accessed: 30.04.2022).

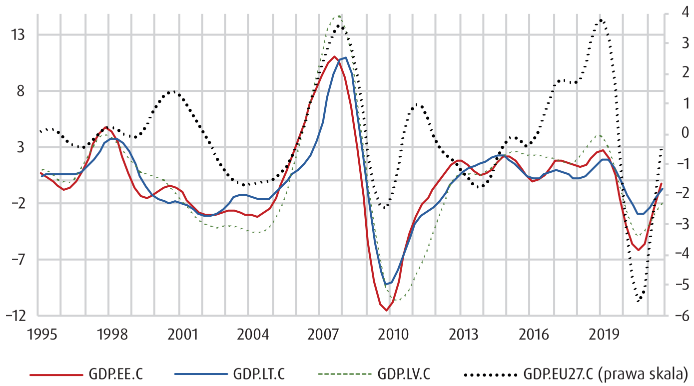
Enclosure 2. Cyclical components of macroeconomic indicators

A. GDP

Visegrad Group states

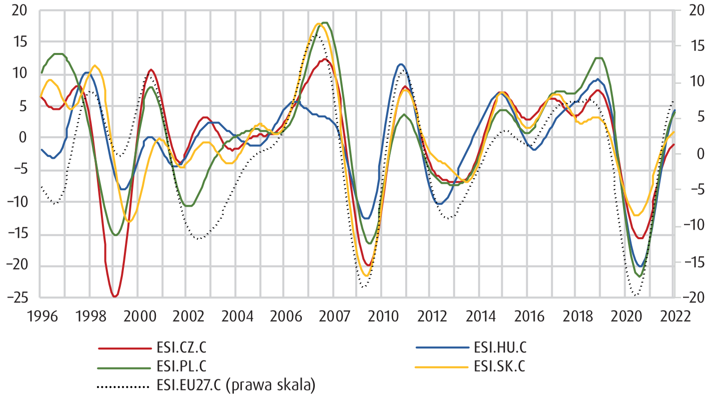


Baltic states

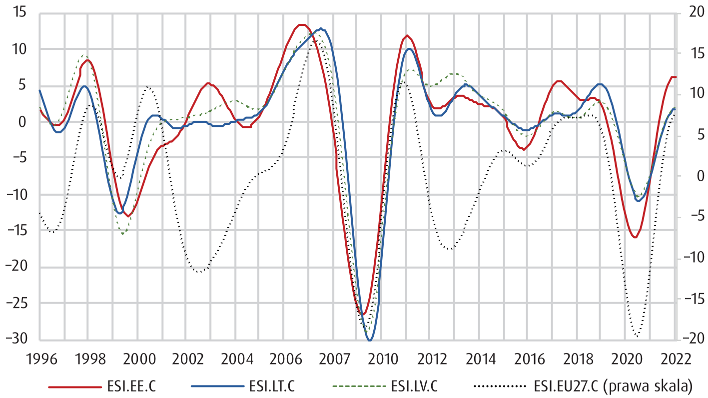


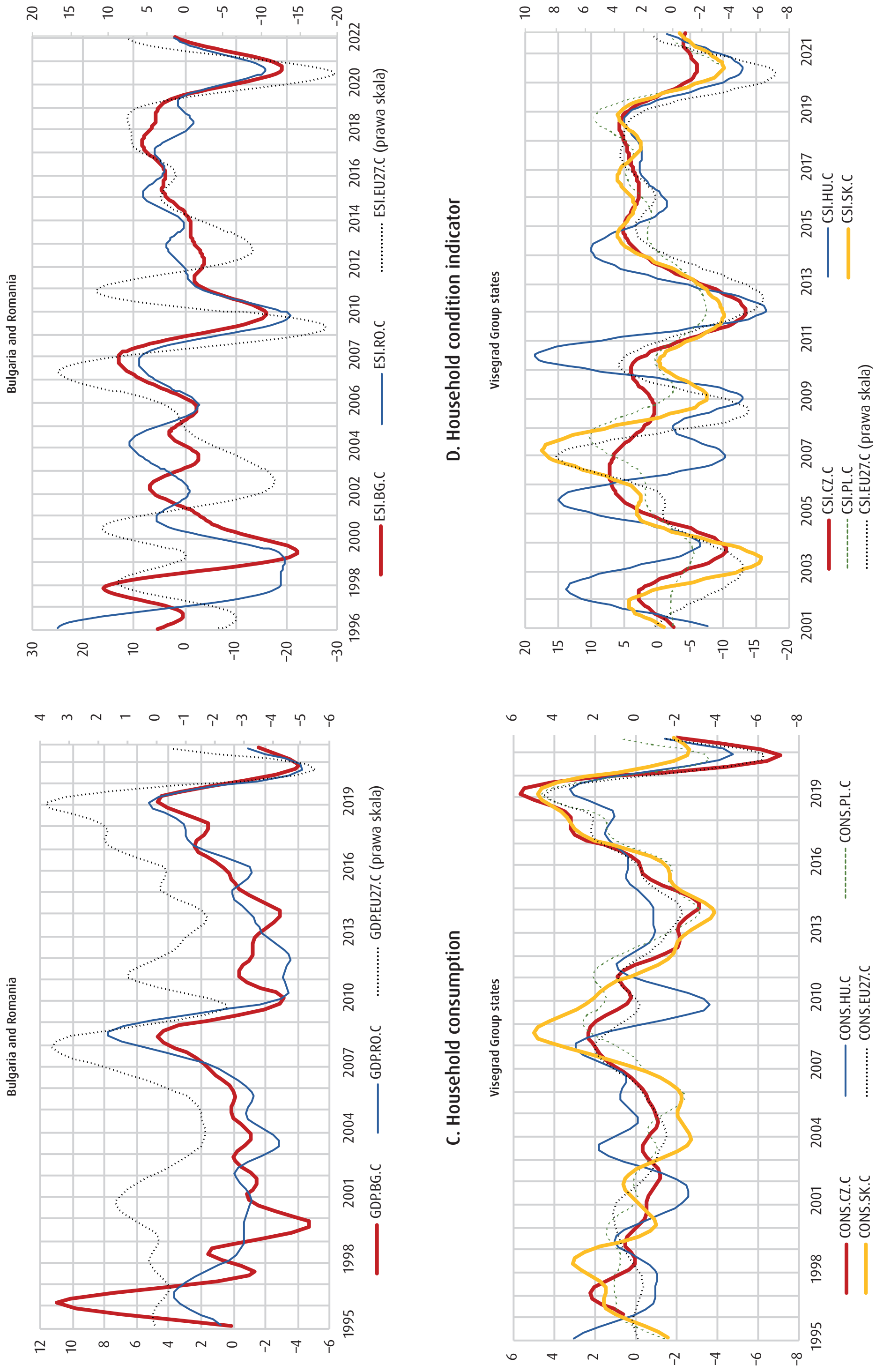
B. Economic sentiment indicator

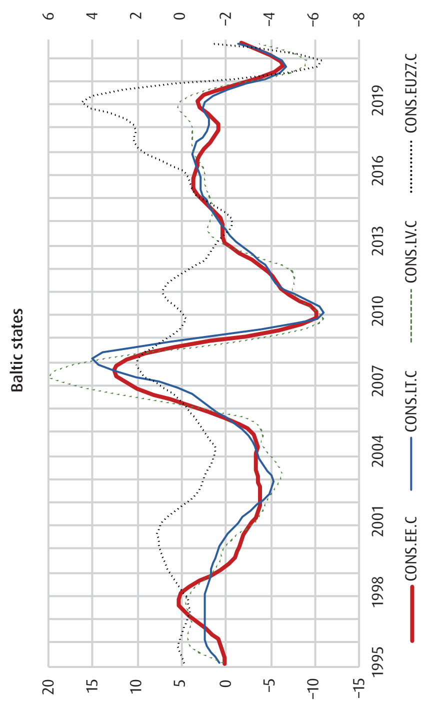
Visegrad Group states

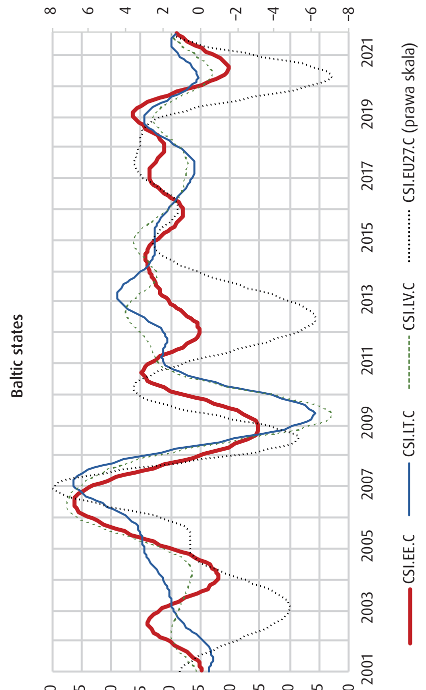


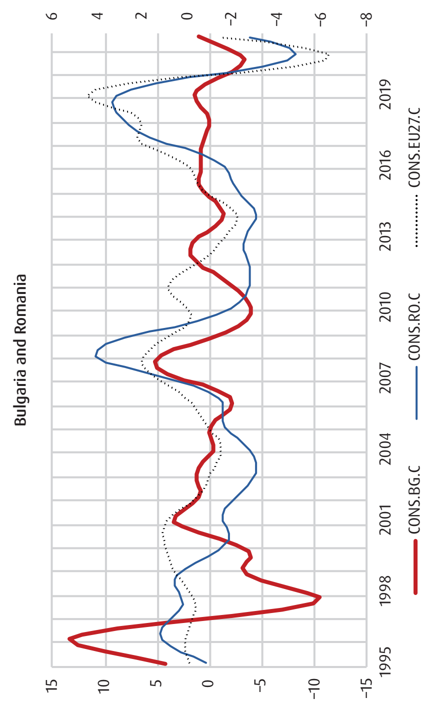
Baltic states

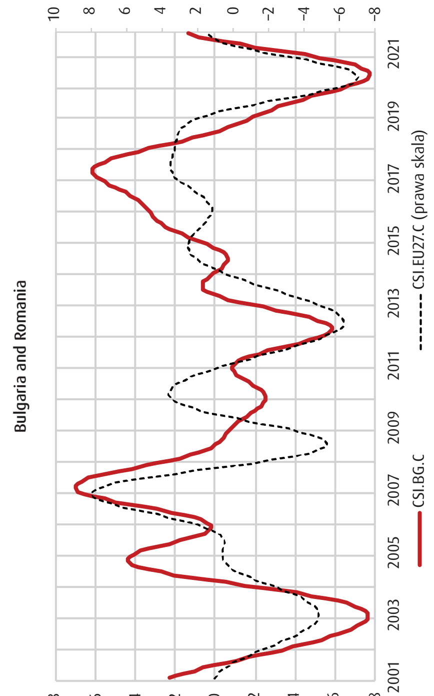



Bulgaria and Romania
GDP.BG.C
GDP.RO.C
GDP.EU27.C (prawa skala)
Bulgaria and Romania
ESI.BG.C
ESI.RO.C
ESI.EU27.C (prawa skala)
C. Household consumption
Visegrad Group states
CONS.CZ.C
CONS.SK.C
CONS.HU.C
CONS.EU27.C
CONS.PL.C
D. Household condition indicator
Visegrad Group states
CSI.CZ.C
CSI.PL.C
CSI.EU27.C (prawa skala)
CSI.HU.C
CSI.SK.C


Baltic states
CONS.EE.C
CONS.LT.C
CONS.LV.C
CONS.EU27.C

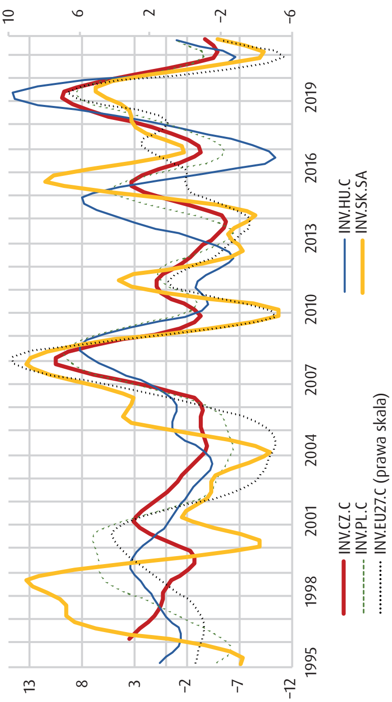

Baltic states
CSI.EE.C
CSI.LT.C
CSI.LV.C
CSI.EU27.C (prawa skala)


Bulgaria and Romania
CONS.BG.C
CONS.RO.C
CONS.EU27.C

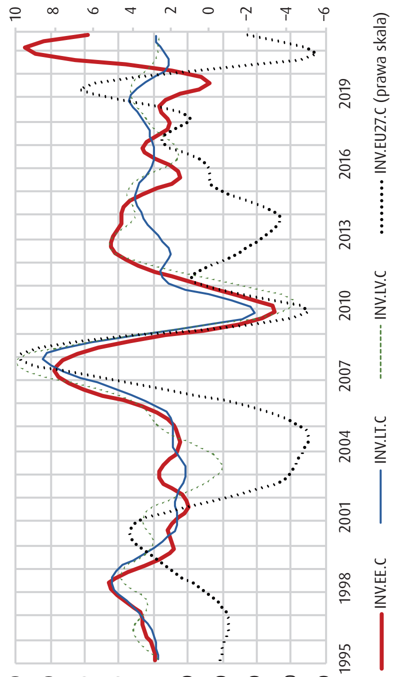

Bulgaria and Romania
CSI.BG.C
CSI.EU27.C (prawa skala)

E. Investment (gross expenditure for fixed assets)

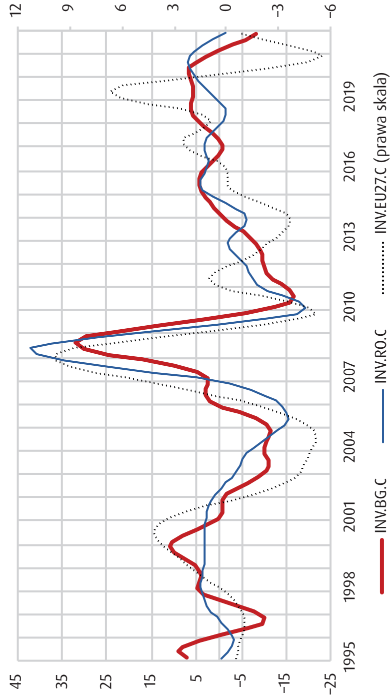
Visegrad Group states



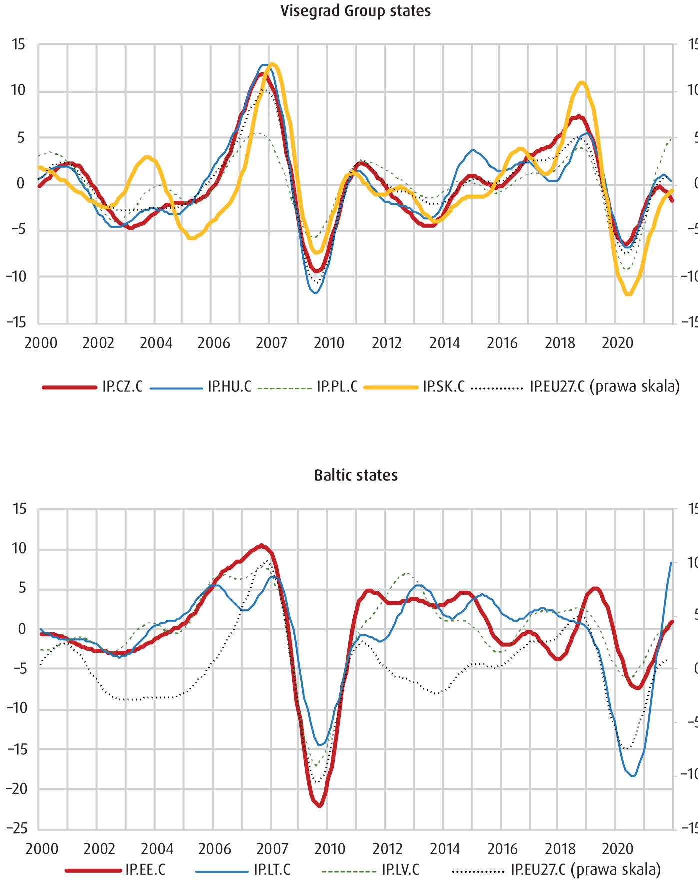
Baltic states



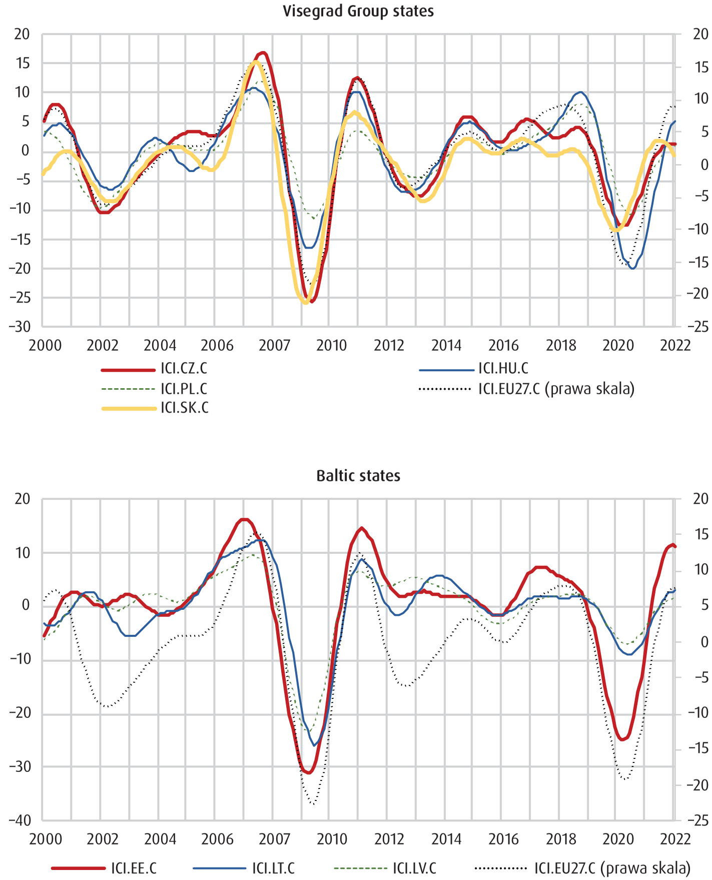
Bulgaria and Romania

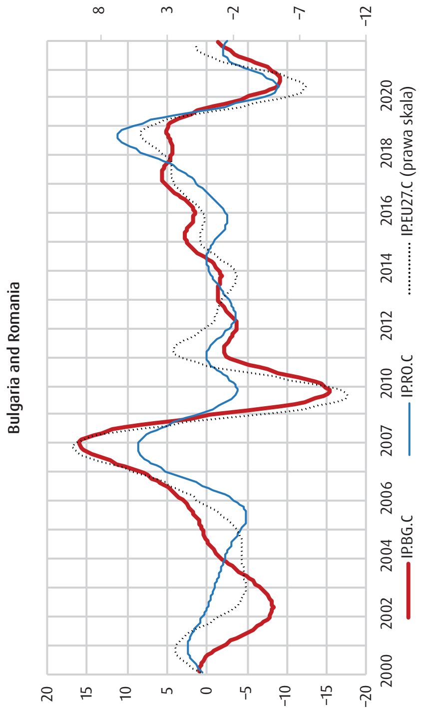


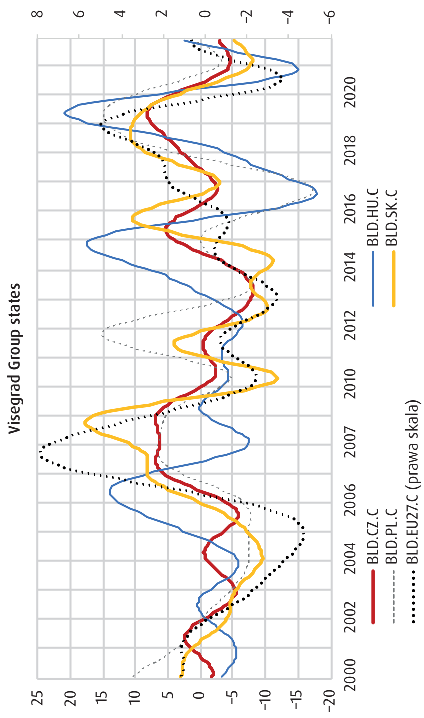
F. Sold production of the processing industry



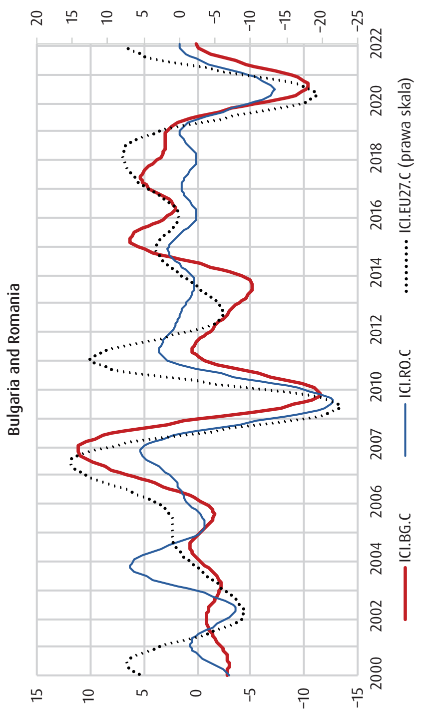
G. Industrial confidence index

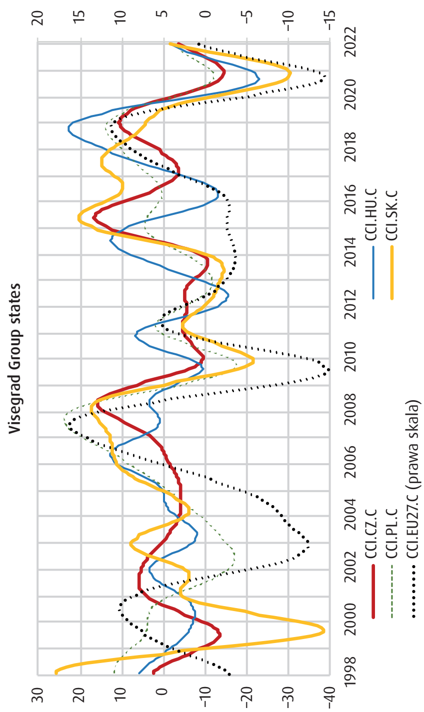




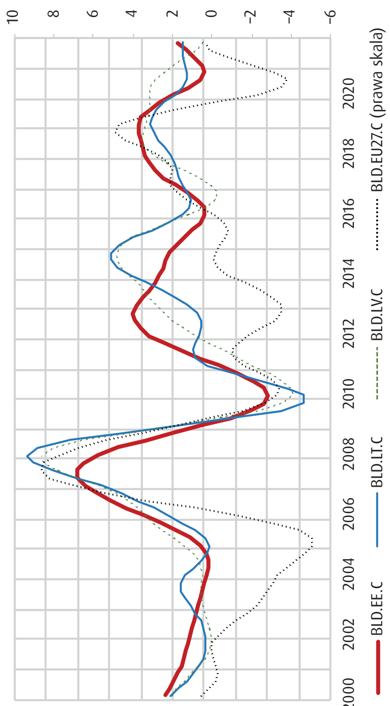


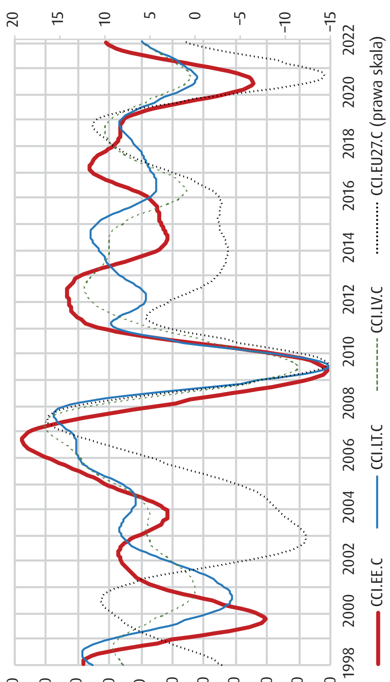
H. Sold production of the construction and assembly industry

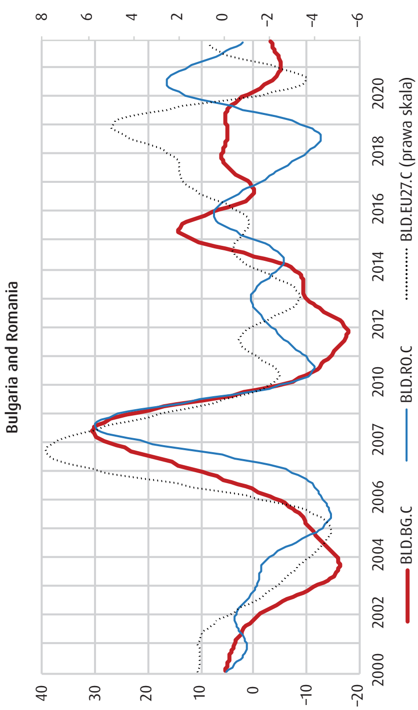


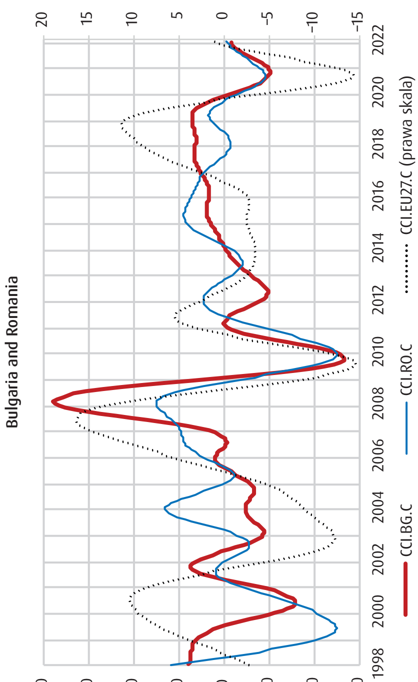


I. Construction confidence index


Baltic states
BLD.EE.C
BLD.LT.C
BLD.LV.C
BLD.EU27.C (prawa skala)

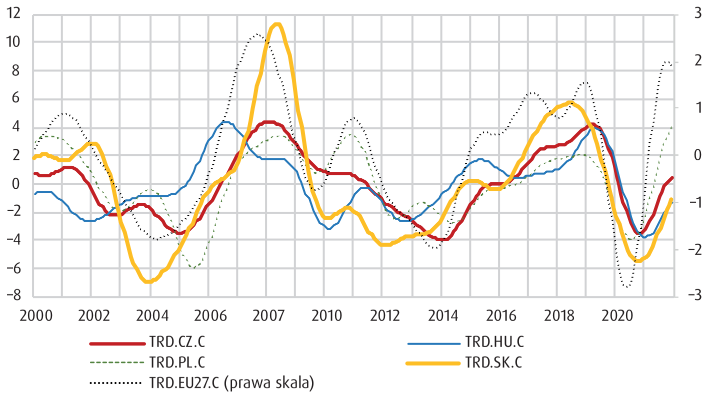

Baltic states
CCI.EE.C
CCI.LT.C
CCI.LV.C
CCI.EU27.C (prawa skala)


Bulgaria and Romania
BLD.BG.C
BLD.RO.C
BLD.EU27.C (prawa skala)

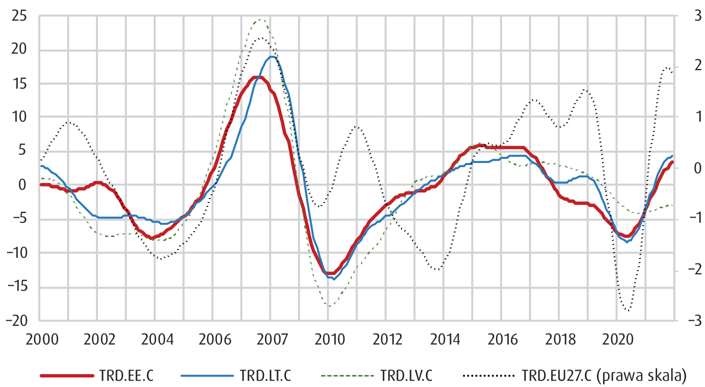

Bulgaria and Romania
CCI.BG.C
CCI.RO.C
CCI.EU27.C (prawa skala)

J. Retail sales

Visegrad Group states

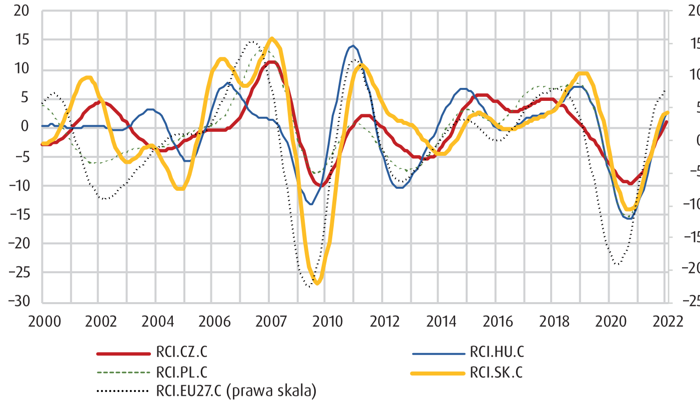


Baltic states

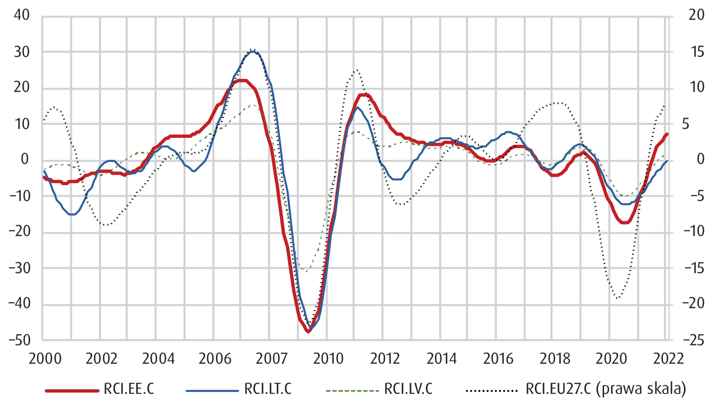


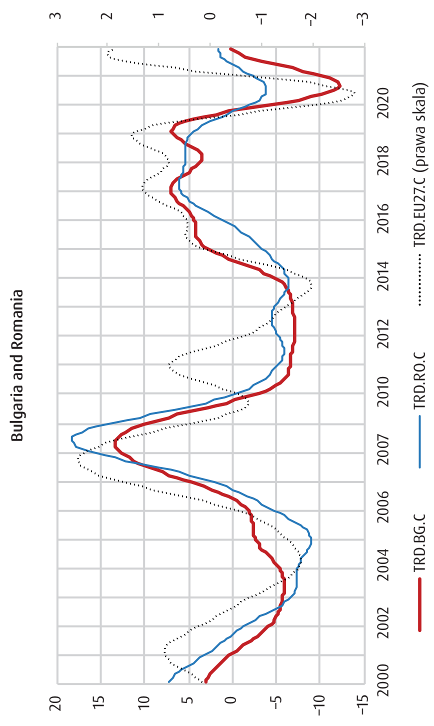
K. Retail confidence index

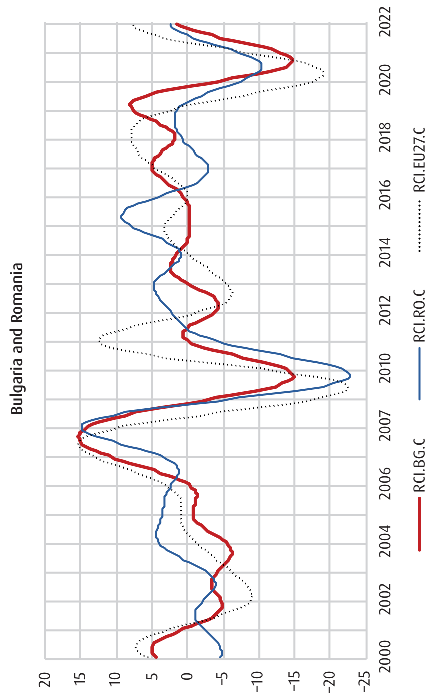
Visegrad Group states



Baltic states







Source: self-reported data.

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FINANCIAL AFFORDABILITY OF HOUSING IN CEE COUNTRIES AMID CHANGES IN MONETARY POLICY

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Paweł Niedziółka

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Abstract

This chapter presents an analysis of the price and credit availability of housing in CEE countries between 2016 and 2021. The study comprises some data on home price dynamics, changes in disposable income, monetary and macroprudential policies, as well as on internal lending policies of banks throughout the region. Our calculations show that there are significant structural differences in the financial availability of housing between individual countries. Housing is the most affordable in Bulgaria, Lithuania, and Hungary, whereas its availability is the lowest in Poland, the Czech Republic, and Slovakia. Moreover, over the last five years in all CEE countries, except for Romania, the financial availability of housing has decreased.

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Ensuring affordable housing for every European Union citizen has recently become one of the priorities of the European social policy. Since 2017 housing has been one of the European pillars of social rights (European Pillar of Social Rights – EPSR), and in 2020 the European Commission (EC) pledged to include Sustainable Development Goals of UN (SDGs) in the European Semester, according to No. 11.1 all citizens should be granted access to suitable, safe and affordable housing. However, achieving this goal may pose a major challenge, particularly for CEE countries which have been grappling with housing shortages inherited from the transformation period, and at the same time decided to conduct a housing policy based on the market mechanism of allocation, i.e. fast privatisation of real property and multidimensional promotion of mortgage loans to individuals, as well as relatively low public spending on the construction and maintenance of council and subsidised housing resources [Czerniak, 2019]. This model of housing policy is particularly sensitive to the financial markets' volatility as it relies on financing the construction of new property with mortgage loans taken out by individual clients [Bohle, 2014]. As a result, when monetary policy is tightened, which is the case currently in CEE economies, the ability to run up more mortgage debt shrinks and the existing mortgage loans become difficult to repay. As the analysis of the previous mortgage loan cycles on the housing market shows, it leads to the worsening of the situation in the construction business, causes increased credit risk in the financial sector and a lower ability to meet citizens' housing needs, which finally has a negative effect on the entire economic situation [Leamer, 2015].

The aim of this chapter is to study changes in the financial availability of flats – purchased both with cash and mortgage loans in CEE countries, as well as indirectly to assess the impacts of the current tightened monetary policy on the situation of developers, funds investing in apartments for rent and regional banks. The financial potential of households to buy housing units in particular CEE countries in the years 2016–2021 was also compared. There were two arguments for adopting a 5-year study period. Firstly, in some CEE countries major changes in the monetary and macroprudential policy were observed, while in other countries of the region monetary policy parameters remained unchanged. Secondly, 2016–2021 were the years of the greatest surges in property prices in CEE economies after the global financial crisis of 2008, which could have a major effect on the financial availability of homes.

The presented study consists of three parts. Part one includes a description of factors affecting the financial availability of housing units in CEE countries. In part two the findings of the quantitative analysis were outlined, proposing two indicators that can be calculated for the financial availability of flats in 2016–2021. Part three presents expert analysis of how the shrinking financial availability of housing in recent quarters affects the condition of developers and development of the Private Rented Sector (PRS) as well as the activity of banks on the housing market and potential changes in the credit policy in this area.

Determinants of the financial availability of housing

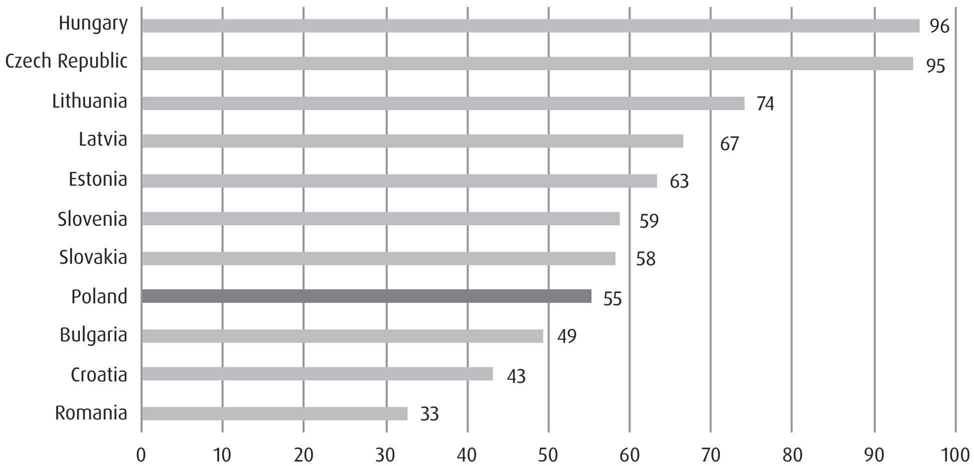
Financial availability of housing has no universally adopted definition in economic sciences. There exist numerous research approaches which can be divided into three main groups of ideas: financial availability for tenants, financial availability for the current property owners and financial availability for prospective property owners [Robinson, Scobie, Hallinan, 2006]. The study discusses the latter of the three concepts. Focus on the financial availability of housing for future owners corresponds to the intention of presenting the analysis of the effects monetary policy has on the ability of financing the purchase of housing units and indirectly on the condition of the property and financial market. Therefore, the definition of housing availability first proposed by Hulchansky [1995, p. 471] was adopted, according to which a household experiences a home availability problem if it has to pay more for the flat purchase than a specified proportion of its income. This definition is useful because it comprises also the people who buy property with mortgage loans, which is the main way of obtaining ownership of housing units in CEE countries for low and medium income individuals [Caturianas, Lewandowski, Sokołowski, Kowalik, Barcevičius, 2020].

Financial availability of housing in this understanding is shaped by three basic factors: property prices, population incomes and availability of mortgage loans, however the latter criterion depends on the parameters of the monetary policy, macroprudential policies and the credit policies of banks themselves. Each of these factors in relation to all CEE countries in the years 2016–2021 will be characterised below.

Housing prices

In all countries of the region we have recently seen a boom on the housing markets, yet particular domestic markets differed as to the scale and time period of the expansion. The highest rises were observed in Hungary and the Czech Republic, where between the beginning of 2016 and the end of 2021 the housing prices doubled (Figure 1) and the price growth rate slowed down only towards the end of the studied period. In the south of CEE – in Romania and Croatia – the prices were increasing much slower and the boom lasted only three years (2016–2019) and faded when the pandemic broke out. In most economies of the region COVID-19 caused only a short term slump in prices (or a slow-down) in mid 2020 which was followed by accelerated rises.

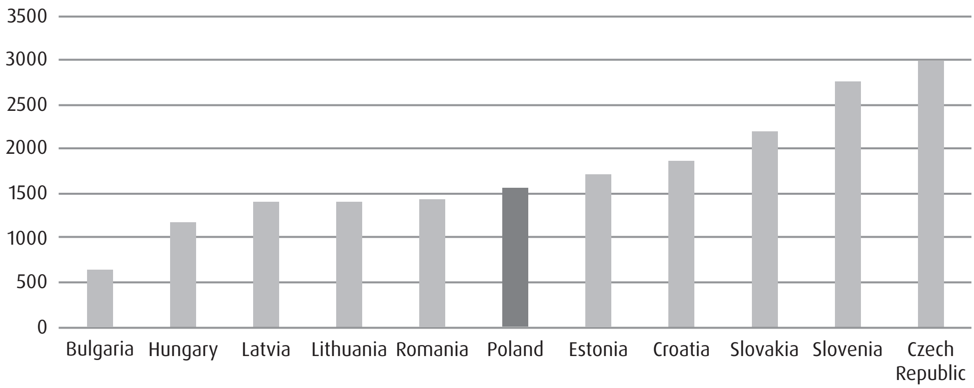
Figure 1. Accumulated housing price rises between Q1 of 2016 and Q4 of 2021 (%)



Source: self-reported data based on Eurostat.

At the end of 2021 flats were the most expensive in the Czech Republic where the average price for a square meter of a housing unit reached 3 thousand euros (Figure 2). Slightly lower prices were noted in Slovenia (2.8 thousand euros) and Slovakia (2.2 thousand euros) euros). Property was the cheapest in Bulgaria (0.7 thousand euros) and, despite very steep rises of the recent years, in Hunagary (1.2 thousand euros). The prices of housing in Poland fluctuated around the region's average and amounted to 1.5 thousand euros for one square meter. It should be also noted that in all CEE economies there are significant internal discrepancies in housing prices – between their capital cities, other large cities and smaller towns as well as rural areas. Relatively expensive flats (versus the national average) were found in the capital city of Bulgaria (the prices of housing in Sofia are almost two times higher than the country average), whereas the smallest difference between the prices of property in the capital city and the national average was observed in Croatia (+10%), which is most likely the result of very high popularity of housing located at the seaside, purchased mostly for its tourist value.

Figure 2. Average price per one square meter of housing property in Q4 in 2021 (EUR)



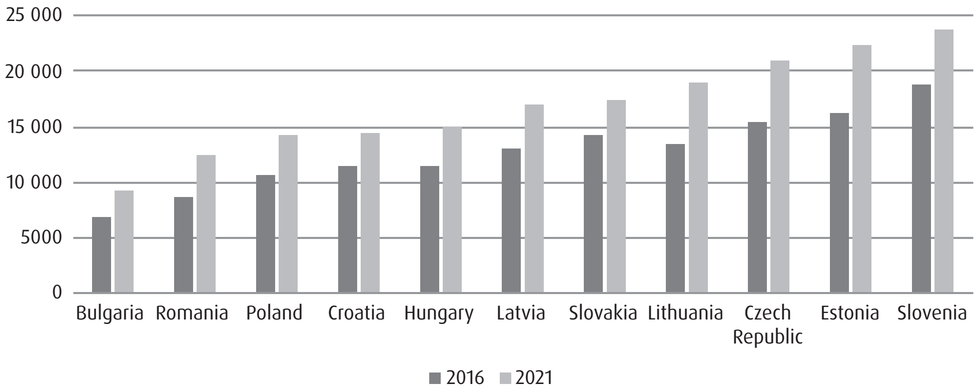
Source: self-reported data based on external data sources (Table 2).

Population incomes

In all economies of the region in the years 2016–2021 national disposable income per one citizen recorded a nominal growth (Figure 3). Based on AMECO[1] data (nominal values in domestic currencies) we calculated that in the studied period disposable income increased the most in Romania and Hungary – mid-year rises of 9.5% and 8.6%. Yet, in Slovakia, Slovenia and Croatia these increases were the slowest and in the average annual perspective fell into the 4–5% bracket. It should be noted that in 6 out of 11 countries disposable income temporarily decreased in 2020 as a result of the pandemic. The hardest felt was the income slump in Croatia (of 5.4%). In Poland, on the other hand, due to extensive government rescue programmes, disposable income in 2020 was growing the fastest in the studied group of countries (by 2.1%).

[1] We estimated average prices based on the data triangulation from various available sources for 2020, then based on Eurostat data we conducted a time-series extrapolation for the years 2016–2021 (Table 2).

Figure 3. Change in the national disposable income per capita in the years 2016–2021 (EUR)



Source: self-reported data based on AMECO data.

In CEE substantial structural differences are observed in the level of the national disposable income ***per capita*** (Figure 3). The wealthiest country of the region, Slovenia, in 2021 had the national disposable income *per capita* almost two times higher than Bulgaria, the poorest country of CEE. A slow, yet systematically progressing process of converging with other EU countries should be treated as a positive circumstance for all CEE economies. For example, in Poland in 2015, the abovementioned income accounted for 37.8% of the EU average, and in 2021 it already reached 43.5%.

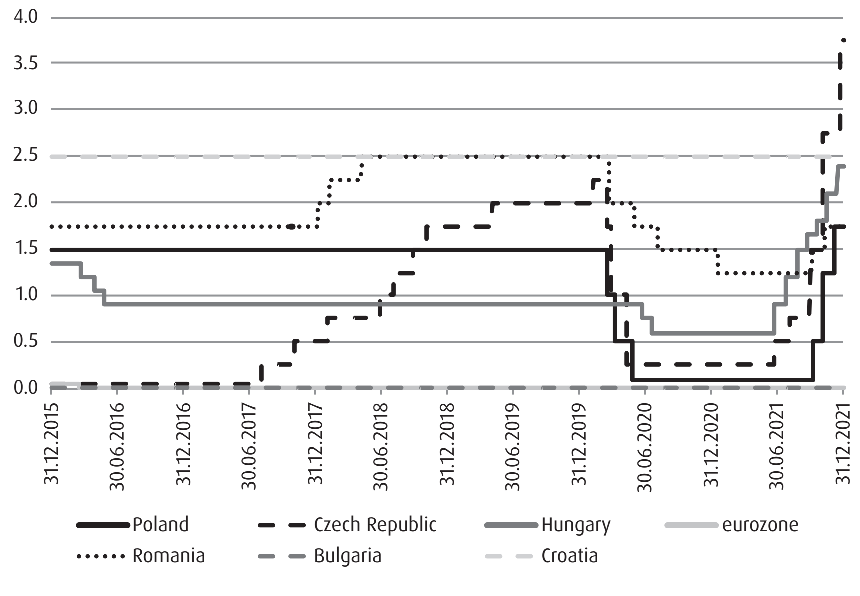
Monetary policy

The studied time period can be divided into three sub-periods in terms of the monetary policy parameters:
1) pre-pandemic stabilisation,
2) easing of lending terms during the pandemic, and
3) rapid tightening of the monetary policy in response to the fast-rising inflation in 2021.

During the first stage which lasted from the beginning of the previous decade to the start of the COVID-19 pandemic, in Q1 of 2020 interest rates (despite slight fluctuations) stayed at a fairly stable level all across the region (Figure 4). The only exceptions were the Czech Republic and Romania where central banks were tightening their monetary policies. During the pandemic (the second sub-period) the entire region saw interest rates being slashed. Only in the countries of the eurozone[2], as well as in Croatia and Bulgaria interest rates did not fall. The third phase of conducting the monetary policy started in mid 2021 and lasted until the end of the studied period. It has been characterised by quickly rising interest rates in response to the growing inflation. The first to raise interest rates was the central bank of the Czech Republic, followed by central banks of Hungary, Poland and Romania. Until the end of 2021 the cycle of monetary policy tightening had not begun in the eurozone countries, as well as Croatia and Bulgaria.

The above analysis indicates that there are considerable differences in the monetary policies conducted by CEE countries in the studied period. This provides a conducive ground for comparative studies because when the observable trends on the housing markets and in terms of income are similar, it is the interest rate fluctuations that become a key factor affecting the financial availability of housing.

Figure 4. Basic central bank interest rates in CEE countries (%)



Source: self-reported data based on ECB data and countryeconomy.com (accessed: 15.03.2022).

2 We have used this data base as it has the information on the levels of disposable income for 2021 of all the countries in the region. Estimates referring to the economies which had not reported their data by the time the study was finished (30.04.2022) derive from EC forecasts.

Macroprudential policy

Macroprudential policy tools are universally employed by EU countries and their catalogue is very wide. Taking into account the aim of this study, this sub-section will deal only with these instruments which apply specifically to the home loans secured by a mortgage. That is because they are of paramount importance for establishing a maximum amount of the mortgage loan that a bank will be able to make. The most popular of them are maximum values for the lending period defined in banks' credit and relations policies: Loan-to-Value (LTV) – of the loan amount to the value of the mortgaged property, Debt-to-Income (DTI) – of the loan amount to borrower's income, and Debt Service-to-Income (DSTI) – of the amount of the loan monthly repayment to borrower's income. As the application of these tools varies across the CEE region, below we decided to deal with the policy of each country individually.

Table 1. Application of macroprudential policy tools affecting the maximum available amount of a mortgage loan

	DTI or DSTI	LTV	Other
Bulgaria			
Croatia	x	x	
Czech Republic	x	x	x
Estonia	x	x	x
Lithuania	x	x	x
Latvia	x	x	x
Poland	x	x	x
Romania	x	x	x
Slovakia	x	x	x
Slovenia	x	x	x
Hungary	x		x

Source: self-reported data based on ESRB and IMF data [2022].

In December 2018 Bulgaria declared a change in national legislation aimed at creating a legal framework for macroprudential policy. According to the new legal order, the central bank has competencies to apply LTV, DSTI and DTI indicators as well as to set the maximum lending period and terms of repayment. Despite that, Bulgaria has not officially reported any use of the above mentioned macroprudential policy tools according to the standards adopted by other member states.

In Croatia using these tools is relatively uncommon. From October 2006 the adopted LTV limit was at 75% and it remained unchanged for a long time. The same regulation stipulated that the monthly loan repayment may not exceed the amount of income, which meant that the DSTI limit was at 100%. This criterion was tightened at the beginning of 2018 by an obligatory deduction of a minimum cost of living from the income of a given borrower when calculating DSTI.

In the Czech Republic a mortgage loan may not be granted for a period longer than 30 years. Simultaneously, clients who have already taken out mortgage loans, can get cash loans for a maximum period of 8 years. This regulation has been in force since 16 June 2015. Since 1 April 2017, LTV for mortgage loans may amount to a maximum of 90%, since 1 October 2018 the applicable DSTI limits are 45% and DTI – 9. However, the use of both tools was suspended in Q2 of 2020 for the time of the pandemic and brought back in a slightly milder form at the beginning of April 2022.

On 1 March 2015 in Estonia a package of macroprudential policy instruments was implemented including: maximum LTV of 85% (or 90% with additional guarantees), DSTI of 50% and a maximum lending period of 30 years. While calculating creditworthiness based on the DSTI indicator the higher of two interest values should be used: the current interest rate plus 2 p.p. or 6%. Loans for which the above parameters have not been met, may not account for more than 15% of the newly granted loans by a given bank.

In Lithuania since November 2015 DSTI limits have been in force accounting for 40% and 50% with a market interest rate at 5%. The bank may, as an exception, renounce the rule and grant a loan with DSTI of up to 60%, but only for a maximum of 5% of the newly made loans. At the same time, the maximum allowed lending period is 30 years, and the LTV limit, in force since 2011 amounts to 85%.

In Latvia since 2014 LTV may not exceed 90%, however the limit can be increased to 95% providing the government guarantee programme is applied. In June 2020 it was slashed to 70% but only in relation to the property purchased for rent. Moreover, since 2020 the maximum lending period has been 30 years. Until 1 June 2020 in Latvia, the limit of DSTI had been progressive, dependent on the income set against the minimum wage – it stood at 10% of the income equal or lower than 0.7 of the minimum wage and could reach even 40% for the income over 3-times the minimum wage value. The system was complemented with the DTI limit which since June 2020 has not been allowed over 6.

In Poland the value of the LTV indicator at the moment of the loan disbursement may not exceed 80% for housing property. It is possible to increase LTV up to 90% if part of the exposure exceeding 80% of the property value is properly insured or secured e.g. with funds in the bank account. These regulations have been in force since the beginning of 2017. At the same time, for new loans, there are no maximum limits on DSTI, but the supervisory bodies recommend that banks pay special attention to the exposures where DSTI (calculated with an interest 2.5 p.p. higher[3] than that at granting of the loan) exceeds 40% for the income below average and 50% for other incomes. Moreover, when assessing creditworthiness, banks should be assuming a maximum 25-year lending period with mortgage loans made for not longer than 35 years. Both of these regulations have been in force since the beginning of 2014 and are treated by banks as equivalent to formal limits.

Romania has been using limits on DSTI indicators for two decades now. They are varied depending on the purpose of the loan and the currency of it (they tend to be lower for loans in foreign currencies), and over time have been frequently updated. According to the regulations in force since 2019 for newly granted mortgage loans denominated in the domestic currency (Romanian leu) DSTI may not exceed 40% and for the liabilities in a foreign currency – 20%. These limits may be higher by 5 p.p. for people buying their first home and do not apply to refinancing loans. At the end of October 2021 new LTV regulations were implemented – a limit for mortgage loans in lei is 85% and 70–80% for loans in foreign currencies. Loans made under the government programme for the purchase of the first home “Prima Casa” are exempt from these limits.

In Slovakia since 2018 a maximum lending period has been 30 years for loans granted by building societies. Simultaneously, since 1 July 2018 LTV may not exceed 90%, and since 1 July 2019 the proportion of new loans with LTV exceeding 80% in the mortgage loan portfolio may be 20% at the most. Moreover, since 1 July 2018 DTI has been reduced to 8, and since 1 July 2019 loans with a DTI between 8 and 9 for specific age and income groups are available, providing their share in the general new mortgage loan portfolio does not exceed 10%. At the beginning of 2020 DSTI was limited to 60%. Previously, those limits were higher, but there were complex guidelines on the income amounts and the loan interest used for the calculation of DSTI indicators.

In September 2016 in Slovenia a new maximum level of the LTV indicator for newly granted loans was introduced at 80%. At the same time, a progressive DSTI limit was set amounting to 50% for incomes below 1700 euros and 67% for the part of income over 1700 euros. In November 2019 a threshold of 1700 euros was replaced with the amount equal to two-times minimum wage, it was also stipulated that after a monthly loan repayment the consumer should be left with the income of at least 76% of the minimum wage. For families have children to support there are also additional restrictions in place. The above mentioned requirements were slightly eased during the pandemic, yet on a discretionary basis, i.e. banks could exempt some months from calculating DSTI if the borrower’s income slumped owing to epidemic restrictions.

3 Estonia, Lithuania, Latvia, Slovakia, Slovenia.

In Hungary there exists a complex and frequently adjusted system of DSTI limits. The currently binding regulations were introduced on 1 July 2019, stating that a maximum allowed level of DSTI is 25–60% depending on the lending period, borrower's income, currency of the loan and frequency of interest updates. A similar complex system regulates maximum allowed LTV indicators which since 2015 have been between 35–80%.

Apart from the above mentioned macroprudential regulations which in principle affect the demand for credit, there are also other macroprudential tools which have an effect on the supply of mortgage loans. The latter include requirements concerning the calculation of banks' capital coefficients, i.e. raising the risk levels of those mortgage loan groups which are deemed more risky by the supervisory authorities. Such measures were implemented in Poland (for mortgage loans in foreign currencies), in Slovenia (for loans with LTV over 60%), Croatia (for loans made to individuals owning more than two housing units), and partly also in Estonia.

Lending policy of banks

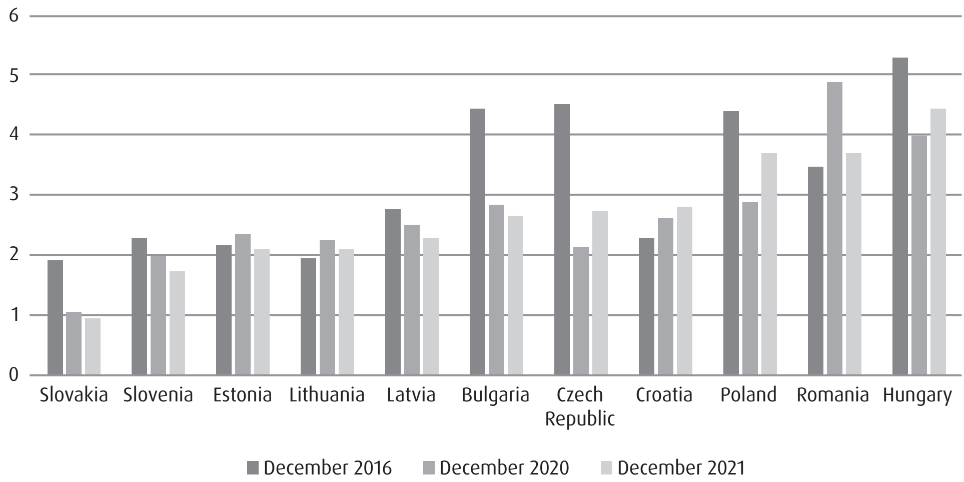
Macroprudential regulations are implemented in order to mitigate the risk of systemic crises in the banking sector like the one that took place in 2008. They are basically not aimed at providing signals as to who should be granted what type of loan by the banking sector. That is why all banks conduct their own credit risk assessment of the consumers applying for mortgage loans, and the limits adopted by banks in terms of LTV, DSTI or DTI indicators which they recognise as safe may be significantly lower than these recommended by the supervisory authorities [Milic-Czerniak, 2022]. As a result, actual credit availability of housing is lower than when calculated based solely on regulatory limitations. Below we have outlined the lending policies adopted by banks in the CEE region for mortgage loans, including the levels of interest and frequency of its updates (so called fixed and floating interest rate loans), the amount of loan in relation to the value of the collateral, and the applied lengths of lending periods.

Mortgage loans in the CEE regions are made mainly by commercial and universal banks. In Croatia, Poland, Slovakia, Slovenia and Hungary such products are also offered by loan associations and building societies, but the market share of these lenders does not exceed a few per cent. Mortgage banks (Hungary) and public mortgage funds (Slovakia and Slovenia) also represent market shares of a few per cent.

Market parameters of mortgage loans in particular CEE economies are highly diversified. It follows both from the above described differentiated models of macroprudential policies and diversified market structures – at the end of 2020 the Polish banking sector was the most competitive, with its HHI index at 0.0753, the most concentrated market was in Estonia (0.2578). Additionally, credit policy parameters were affected by the scale of foreign capital share (from ca. 43% in Poland and Hungary up to 90% in the Czech Republic, Croatia and Lithuania) and the related flow of banking practices and internal regulations, as well as the current financial condition of the banking sector in each of the countries.

The interest on mortgage loans made by banks is a function of many variables, among which the most crucial are: interest rates set by central banks, market expectations about future interest rates, bank margins and the frequency of loan interest adjustments. The importance of other factors than the current monetary policy is shown in the data of the last five years (Figure 5) which demonstrate very high diversity of interest levels among eurozone countries – from below 1% in Slovakia to over 2% in Latvia. Moreover, interest on mortgage loans in those countries was changing at a different pace and in different directions, despite the fact that the reference interest rate of ECB during the last five years stayed almost unchanged.

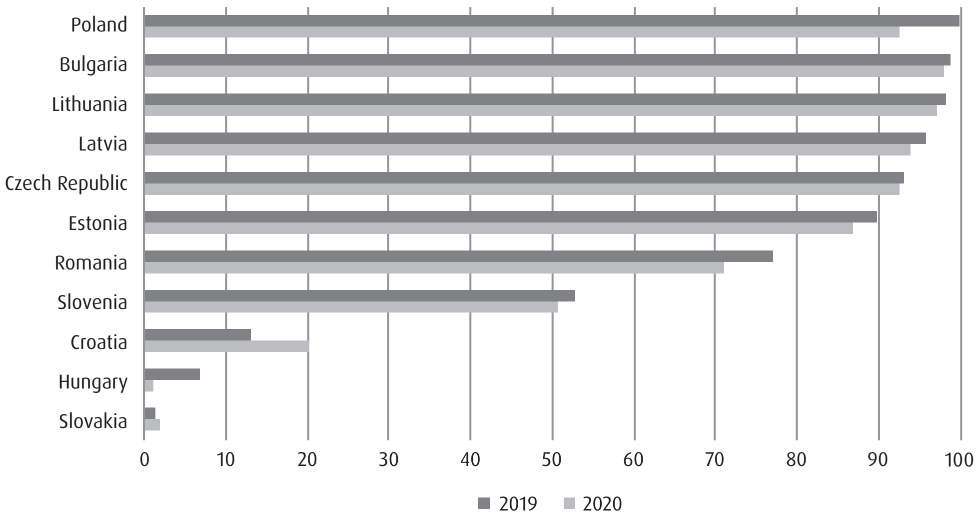
Figure 5. Average interest on new mortgage loans (%)



Source: self-reported data based on external data sources (Table 2).

One of the most important factors of differences between mortgage loan interest levels in various economies is the frequency of interest adjustments. For loans with a floating interest rate (interest updated once a year or more often) the current interest rate on the interbank market (e.g. WIBOR rate in Poland) is much more important, while for fixed interest loans (updated less frequently than once a year) the yields of 2-year, 5-year or 10-year government bonds are more relevant, which is the level of interest rates at the so called long tail of the income curve. There are eight CEE economies (Figure 6) in which banks make loans mainly based on the floating interest rates. Loans with a fixed interest rate are the least popular in Poland where since 2020 their market share has been close to zero. Yet, demand for such products started to grow as clients became aware of the risks of rising interest rates[4]. On the other hand, in Slovakia, Hungary and Croatia the share of fixed interest loans exceeds 80%. Currently, a trend of the share of fixed interest loans being on the rise can be observed all across the CEE.

Figure 6. The share of floating interest mortgage loans (%)



Source: self-reported data based on the recently available data from Hypostat for all studied countries.

The policy of banks in CEE countries related to granting mortgage loans, including the acceptable levels of LTV and DSTI indicators or margins and the general lending propensity has been fluctuating strongly throughout the study period, which resulted from changes in the macroprudential policies as well as from idiosyncratic conditions of particular banks (e.g. profitability of products, cost of obtaining financing, quality of the portfolio, impact of the loan portfolio on meeting prudential norms, changes in the business model).

Based on the data obtained from the surveys provided to presidents of bank loan committees in the CEE region[5], the evolution of mortgage loan policies may be divided into two sub-periods – the first one between Q1 of 2016 and Q2 of 2020, and the second one from Q3 of 2020 till the end of the study period in 2021. In the first sub-

[4] Since April 2022 this requirement has been tightened up to 5 p.p.

[5] According to ECB, in March 2022 the share of fixed interest mortgage loans in Poland reached almost 42%.

period there was a general loosening of the mortgage loan policy criteria throughout the region. The most credit policy easing was noted in Hungary, the Czech Republic and Slovakia. Only in Poland a slight tightening of credit requirements could be observed, while in Lithuania and Estonia easy policies were maintained. In Q3 of 2020 this trend was reversed and practically in all economies, apart from Romania and Slovenia, mortgage loan requirements were tightened. The credit policy conservatism index, used to measure the scale of loosening or tightening of credit policy, is calculated as a difference between the proportion of banks which when asked about tightening/loosening of their credit policy answered they have “significantly tightened” or “tightened” this policy and the proportion of banks which stated that in a given quarter their policy was “significantly loosened” or “slightly loosened” [EMF, 2018; EMF, 2021].

Based on the comparison of the above data sets related to the changes in credit policies and Hypostat [2017–2021] data on the standard length of mortgage lending periods and LTV values, we have conducted a quality assessment of the restrictiveness of the commercial banks’ policies in CEE countries[6]. It may be concluded that in the studied period the easiest mortgage loan policy was employed in the Czech Republic, Estonia and Latvia, and the tightest – in Bulgaria, which reflects the importance of the restrictiveness of internal banking regulations when no active macroprudential policy is in place.

Analysis of the financial availability of housing

Measurement method

In the relevant literature, three most popular groups of measurement methods of the financial availability of housing can be found [Ezennia, Hoskara, 2019]:

1) traditional approach, most frequently applied and based on calculating quantitative indicators [Robinson, Scobie, Hallinan, 2006];
2) behavioural approach, analysing subjective factors affecting property purchase decisions, based mostly on questionnaire surveys [Bramley, 1994; Chasco, Gallo, 2013];
3) extended approach, accounting for additional quality and quantity criteria [Mardani et al., 2015], Gini Coefficient [Wang at al., 2012] and conducting studies of the population mobility between regions [Cheong, Wu, 2018];

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6 These data are collected in a standardised way by central banks and handed over to the entire population of loan committee presidents of banks operating in a given country. More information on the construction of the survey can be found on the website of the National Bank of Poland (NBP) [2022b]. There are no survey results available for Croatia and Bulgaria.

In the first, traditional approach there are three ways of delineating housing availability:

a) income method, a comparison of housing prices and population incomes [Abeysinghe, Gu, 2011];
b) residual income method, a comparison of housing prices and population incomes after basic needs expenditure has been deducted [Stone, 2006];
c) composite method, using linear regression to aggregate various quantitative availability indicators [Tang, 2012].

A quantitative analysis of the use of various methods of measuring the financial availability of housing was presented in the work of Ezennia and Hoskara [2022]. From among 160 studied scientific works, 127 used conventional methods (79.4%), 21 – the behavioural approach (13.1%), and 12 – the extended approach (7.5%). In the traditional approach most dominant were various composite methods, including econometric modelling (77 instances, i.e. 48.1%). The income method was used in 38 publications (23.8%), and the residual income method in 12 works (7.5%).

This study uses the traditional approach, we have applied two indicators to assess the financial availability of housing: the most popular among income methods, i.e. the relation of price to income, and the advanced original method of credit availability of housing. Based on this, a maximum housing area (in sqm) was calculated which an average income consumer is able to purchase at a given average market price, using the mortgage loan financing to the most available degree. We have used the above presented data on average housing prices, disposable income *per capita*, average interest on new mortgage loans, as well as macroprudential policy parameters – the maximum relation of the loan to property value (LTV), principal and interest repayments to income (DSTI) and the loan amount to income (DTI), as well as the maximum lending period and a potential mark-up on interest required while calculating creditworthiness[7]. Additionally, we have adopted an assumption that the required own contribution may not exceed two-times the average annual disposable income. All data have been aggregated in the domestic currency at a quarterly frequency. This approach constitutes an extension of the housing availability measurement method proposed earlier for the biggest cities in Poland [Chinowski, Mokrogulski, 2014]. All data sources and necessary transformations have been set out in Table 2 at the end of the chapter.

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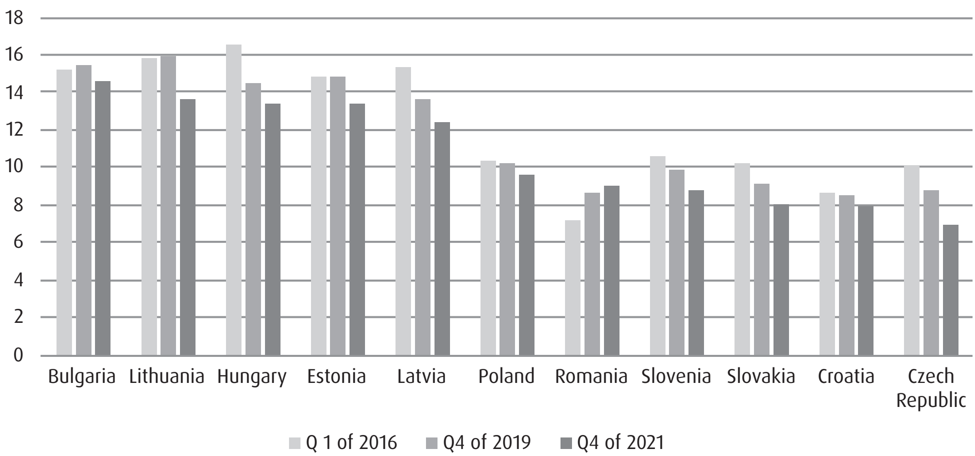
7 The analysis was conducted based on the index the value of which is an average of distribution quartiles in five categories (the higher the index value, the lower the restrictiveness):
1) 100% of the mortgage loan interest;
2) length of the lending period;
3) LTV;
4) share of quarters in which lending criteria were loosened (before the COVID-19 pandemic);
5) share of quarters in which lending criteria were loosened or stayed unchanged (before the COVID-19 pandemic);

Price availability of housing

The conducted analysis shows that the price availability of housing in CEE countries in recent years has been shrinking systematically (Figure 7). The only exception being Romania, where in the years 2016–2021 disposable income was growing faster than home prices. In terms of structural differences in the CEE region two types of economies may be identified: these with a relatively higher price availability of housing in which an average annual disposable income can buy 12 sqm of home, and these with a relatively lower price availability of homes (≤10 sqm). The countries characterised by relatively cheaper housing are Bulgaria, Hungary and the Baltic countries. Homes are more expensive in the Czech Republic, Slovakia, Slovenia, Romania and Poland which additionally has the index of the price availability of homes close to the regional average (9.6 sqm).

Figure 7. Price availability of housing – the housing area which may be bought with the average annual disposable income in a given country (sqm)



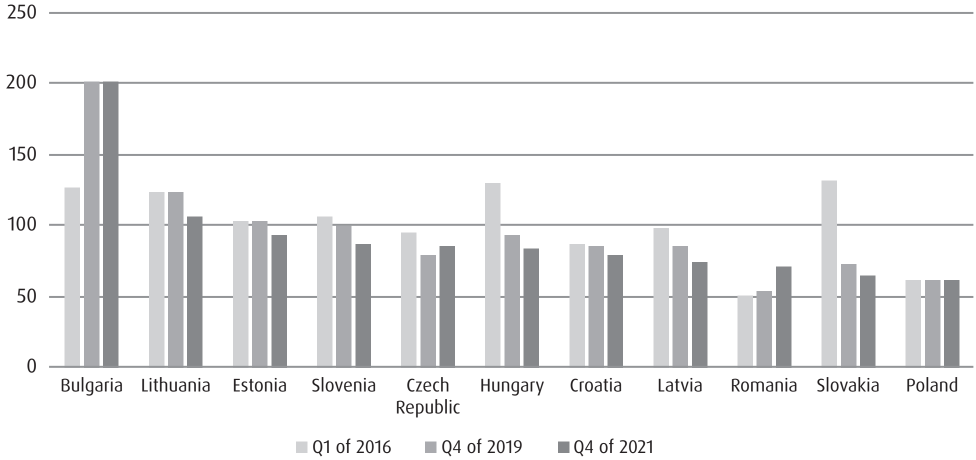
Source: self-reported data.

Credit availability of housing

Credit availability of housing in the CEE region is marked by greater diversity than the price availability (Figure 8). On one end of the scale is Bulgaria where the index of credit availability exceeded in Q4 of 2021 200 sqm, on the other extreme is Poland where during the entire study period the value of this index was 61 sqm. It means that a Pole with an average disposable income and able to fully use the possessed creditworthiness could buy a home (average price) of an area of 61 sqm, while a Bulgarian could purchase a flat of 200 sqm. Such great discrepancies are chiefly the result of highly differentiated macroprudential policies, which in Poland are relatively restrictive (cf. former sub-chapter), while in Bulgaria there exist no formally reported countrywide regulations on the terms of granting mortgage loans.

Apart from a high geographical diversity, the data reveal significant time discrepancies in terms of credit availability of housing, particularly in Hungary and Slovakia, to a slightly lesser degree in the Czech Republic. This results from changes in the macroprudential policies which were first tightened in response to the housing boom, and then loosened as the pandemic broke out (cf. the previous sub-section). The Czech Republic is some of a special case because the pandemic loosening ended there in April 2022. Thus, it was the only country (apart from Romania, where the price availability of homes was on the rise) in which the credit availability of housing in Q4 of 2021 was higher than in Q4 of 2019.

Figure 8. Credit availability of housing – the home area which could be bought using credit financing in particular countries (sqm)



Source: self-reported data.

Finally, it should be noted that the above index of credit availability of homes is of mainly illustrative value and serves the purpose of comparing the impacts of various factors determining the ability to buy homes in CEE countries. The actual creditworthiness is lower in most countries due to particular banks applying more restrictive regulations than these imposed by supervisory authorities. The best example is set by Bulgaria where despite a high index of credit availability the market of mortgage loans is still small because banks conduct a very conservative policy of calculating creditworthiness (cf. previous sub-section). Moreover, the actual creditworthiness is also affected by the level of prices in a given location, the actual flat area (price per sqm is usually falling as the area increases), as well as the scale of income inequalities which may blur conclusions drawn from the analyses of average measures. What is more, despite the adopted restrictions on own contribution at the level of two-times annual disposable income, this amount if often unavailable to many households, which is an extra constrain on their actual creditworthiness in the countries where LTV limits are very tight.

Summary

The above outlined data indicate that the scale of restricting the credit availability of housing in connection with fast rising property prices and simultaneous tightening of monetary policies in some CEE economies was rather insignificant until the end of 2021. In some countries, the impact of interest rate hikes on the mortgage market was limited by maintaining liberal, pandemic macroprudential regulations (the Czech Republic), in others it was constrained by a relatively high share of fixed interest loans (Slovakia, Hungary), and in some, by lack of change in the reference interest rates (the eurozone countries). As a result, a more complex effect of changes in the monetary policies on the financial availability of homes will be felt only in the upcoming years.

Residual data for the first months of 2022 indicate that the scale of slumps in the credit availability of housing, following the tightening of monetary policies, may amount even to 50%. It will be the hardest felt by countries with dominant shares of floating interest rate loans, particularly those from outside of the eurozone, where the total scale of central bank reference interest rate hikes will be most probably the highest, this is a clear indication to Poland and the Czech Republic. Moreover, in both of these countries, macroprudential policies in relation to mortgage loans were tightened significantly in April 2022, which will further restrain the investment capacity of new clients. However, some slump in the financial availability of homes will be seen in all CEE countries. It will be reflected in the condition of the developer sector, situation of the financial sector and PRS segment in which homes for rent are offered by investment funds. Findings of the presented study may thus prove useful to the practitioners of these industries.

For the developer sector, reducing credit availability of housing will mean a visible fall in demand. Although most flats which are currently under construction have been sold out, some difficulty may appear when selling homes scheduled for 2024 and offered to customers in the upcoming year quarters. It will most probably lead to a halt in the price growth rate of housing properties. In some countries and on some local markets the prices of real property may decrease. Prices may be reviewed in Hungary where the housing market has been particularly overheated recently, with a very high probability of price cuts also in the Baltic countries. Reduction in the price and credit availability of housing in most countries of the region may translate into shifting demand towards smaller homes and problems with selling larger area apartments. This market dichotomy will additionally be exacerbated by a keen demand for smaller homes for rent.

Table 2. Data used in the study

Data	Sources	Notes
Home prices (local currency)	Deloitte [2022]; BIS [2022]; Ober-Haus [2022]; NBP [2022a]; Eurostat [2022]	average nominal prices from the primary and secondary market of 2020 [Deloitte, 2022]: for the Czech Republic, Slovakia and Hungary average of Deloitte data [2022] and BIS [2022], for Poland – of Deloitte data [2022] and NBP [2022a], for Lithuania – of Ober-Haus data [2022]; data for the entire country or biggest cities (Lithuania, Poland); time extrapolation of data for quarters using Eurostat base indices [2022]
Interest on new agreements	ECB [2022]; NBP [2022a]; BNB [2022]; Hypostat [2017, 2018]	including bank margins; data for Poland and Bulgaria completed based on the series identical with that used by ECB [2022] (obtained from the local central bank); monthly average data (arithmetical average) to quarterly data; data for Hungary and Romania for the period of January 2016 – July 2017 taken from the Hypostat base [2017, 2018]
Disposable income	EC [2022]	annual data of EC [2022] from AMECO base interpolated to quarterly data using EViews software and Denton method
LTV (Loan-to-Value)	Alam et al. [2019]; MFW [2022]; ERRS [2022]	LTV (regulatory requirements) from MFW base [2022] completed with information from ERRS base [2022]; if no regulatory limits were in place, LTV median of actually granted loans from MFW base was used [2022]; if LTV was internally diversified, the more restrictive value was applied; data for end of quarter
DSTI (Debt-Service-to-Income)	Alam at al. [2019]; MFW [2022]; ERRS [2022]	DSTI indicators (regulatory requirements) from MFW base [2022] completed with information from ERRS base [2022]; if the regulatory limit was not in place (Bulgaria) the value of 60% was adopted (maximum for all countries apart from Slovakia, where the so called subsistence minimum is excluded from the income); data for end of quarter
DTI (Debt-to-Income)	ERRS [2022]	regulatory maximum available only for the Czech Republic, Latvia and Slovakia; data for end of quarter
Maximum lending period	ERRS [2022]; Hypostat [2017, 2018, 2019, 2020, 2021]	Maximum period allowed for calculating creditworthiness; if no regulatory restrictions were applied, the average term of loan agreements was used [Hypostat, 2017–2021; for Bulgaria, Romania and Latvia only data from before 2019] or 35 years (maximum for the studied markets – Croatia, Hungary, Romania); data for end of quarter
Regulatory charge on interest rates	Alam at al. [2019]; MFW [2022]; ERRS [2022]	obligatory chargé a bank must impose on the current interest when assessing creditworthiness (Estonia, Lithuania, Poland); data for end of quarter

Source: self-reported data.

A restrictive macroprudential policy conducted recently in most CEE economies along with a more conservative than before 2008 attitude of banks to making mortgage loans amidst a property market boom means that the risk of a banking crisis caused by a high number of loan defaults will remain very low. To the contrary, in the economies dominated by floating interest rate loans, the profits of banks in the initial periods of monetary tightening are on the rise. Rising interest rates make the assets held in banks' portfolios more profitable, while the interest on deposits and other instruments being banks' liabilities is growing only slightly at the beginning. In a few-year perspective a slump in the financial availability of housing may negatively affect the profits of the banking sector due to a serious reduction in the number of banking products sold. Already starting from mid 2022, it may force more price competition and slashing margins on mortgage loans. Some banks may decide to seek new sources of growth in other market segments, mainly in working capital facilities for companies. These banking products face still a vast growth potential in CEE countries.

The greatest winners of the falling financial availability of homes will be funds investing in housing for rent. Lack of ability to buy own homes, even financed with credit, will boost the demand for rented property, particularly long-term and with high quality of customer service. This professional market segment has been recently an area of investment for international capital funds, particularly in Poland, Hungary, Slovakia and the Czech Republic. This trend will most probably continue, and the demand for purchasing property for rent will become a driving force for large developers who can annually build several thousand high quality flats at competitive prices in attractive locations

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ENERGY TRANSITION OF AUTOMOBILITY – GLOBAL TRENDS AND NATIONAL PERSPECTIVES

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Abstract

The subject of the research is the analysis of energy transition of the automotive market in the passenger car segment. The study aims to identify possible scenarios of the process of eliminating CO_2 emission vehicles from road traffic and replacing them with a new generation of zero-emission vehicles with a motor powered by electricity from a battery. The development of passenger car market was designed using the method of scenarios planning. The authors selected a team of experts, together they identified a set of factors important for changes and prepared three scenarios: 1) base scenario, which optimistically assumes that the market will develop at the current pace; 2) scenario of limited approval for electric passenger cars, reflecting lower popularity of electric vehicles than previously expected; 3) scenario of decline in supply and demand for new cars due to a significant decrease in the wealth of the society. The scenarios include quantitative estimates of the structure of Poland's new car registrations in 2022–2025 and in 2030. Based on these estimates, a quantitative analysis of a hypothetical reduction in the consumption of liquid fuels and gas was carried out. The resulting reduction in CO_2 emission was also estimated. The study concludes with recommendations for public authorities and the automotive industry regarding their energy, climate, and transport policies.

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The automotive industry is shifting to electromobility right in front of our eyes. The track and time frame of this process are still unknown, though. They depend on a range of exogenous and endogenous factors, whose direction and strength may differ.

The team of the Institute of Infrastructure, Transport and Mobility (IIiTM) of SGH has been studying e-mobility for years now [Gajewski, Paprocki, Pieriegud, 2017, 2018, 2019; Paprocki, 2017]. The goal set by the authors of this article is to distinguish possible scenarios of eliminating emission-producing vehicles from road traffic and replacing them with new zero-emission vehicles or vehicles with closed carbon (CO_2) loop that will ensure that road vehicles, especially passenger cars, will have globally neutral balance of emissions and CO_2 capture. The experience gained so far shows that the best described way to reach zero emission remains a passenger car with a motor powered by an electric battery. Analysis of the process of marketing battery electric vehicles made it possible to learn about barriers that have been identified and described in recent years. These were mostly demand-related hurdles, such as:

a) lower than forecast popularity of electric vehicles;
b) considerable decline in available income of an average car user.

These demand-side obstacles provided a basis for three alternative scenarios of individual automobility development: the base scenario, the scenario of limited approval for electric passenger cars, and the scenario of decline in supply and demand for new passenger cars.

The anticipation was made using the scenario development method [Kononiuk, 2012]. The authors first selected experts, and then identified with them a set of relevant factors, in order to finally develop three scenarios of energy transition of individual automobility. The scenarios were being developed from March to late May 2022 as a part of internal works of the IITiM team, to be further subject to a critical analysis during discussion sessions with the participation of external experts. The scenarios cover quantitative estimates of first registrations of new cars in Poland in 2022–2025 and in 2030. Based on these estimates, a quantitative analysis was carried out of possible reduction of CO_2 emissions from combustion engines, if some cars would be replaced by EVs. The analysis made a model assumption (differing, however, from the actual situation in Poland) that only energy from renewable sources would be used to charge car batteries. The final part of the article provides recommendations that can help to achieve the climate goals faster, with rational use of resources and capital.

Premises of energy transition of automobility

The phenomenon of individual automobility

19th century was the time of inventions that paved the way for the production of vehicles with mechanical drive. They included technical solutions that contributed to the creation of two branches of wheel transport – railway and road. Individual mobility was developing next to organised transport of people and goods. Its phenomenon was connected with the social position of men, who in the first half of the 20th century found that their personal involvement in the development of this form of satisfying mobility needs is convenient and prestigious. The willingness to become an automobile driver became a vital reason to search for a well-paid job, ensuring financial resources necessary to buy a passenger car and to maintain it. Relative wealth of passenger car users, combined with the mass character of the phenomenon, shaped conditions for considerable flows of money from consumers to the automotive industry, and newly emerging sector of services for drivers and their vehicles.

A factor supporting the development of individual automobility was involvement of public authorities (federal and state bodies in USA and government bodies in Europe and other parts of the world), as well as local governments, in the construction of road infrastructure. For many decades of the 20th century it was detached from the development of other elements of the technical infrastructure, including electricity grid. A huge advantage was the possibility to refuel a passenger car with liquid fuel from geographically dispersed tanks using simple hand pumps.

Accumulation of capital in these two – machine and oil – branches of industry allows for financing development research by car makers and fuel producers, as well as their suppliers. As a consequence, technology solutions that improved safety and mobility of road transport, and, most of all, raise the comfort of driving a passenger car, were continuously upgraded.

In 1920s in USA, and then in 1950s in the Western Europe an automobile became the basic consumer good owned by a substantial part of the society. The Central Europe, including Poland, reached a comparable level of individual automobility after its system transformation. At the turn of the 20th century a lot of women became car owners and users, which reduced the phenomenon of transport exclusion of females, especially those living in poorly urbanized areas.

Interestingly, individual automobility phenomenon is characterised by readiness of most households to incur relatively high and periodically growing costs of purchasing and exploiting a passenger car. In the period of oil crisis in 1973–1974 and in 2021–2022, when oil prices grew dramatically, the demand for fuel did not drop significantly. Growing fuel costs are definitely painful for many users, but higher expenses for a passenger car result in reducing expenses for other consumer goods.

Individual automobility is a form of economic activity and a consumer behaviour that is connected with using passenger cars. For the sake of this study we have prepared a list of various types of vehicles that are now used in everyday life (Table 1).

Table 1. Car classification by drive type

Electric vehicle (EV)	Electric vehicle
Battery electric vehicle (BEV)	Electric vehicle driven only by electric power accumulated in batteries.
Hybrid electric vehicle (HEV)	Hybrid electric vehicle equipped with two motors – combustion and electric one, which can work separately or simultaneously. In HEVs the electric motor is usually ancillary. The sub-category of mild hybrid electric vehicle (MHEV) covers vehicles in which the work of electric motor is very limited.
Plug-in hybrid electric vehicle (PHEV)	A hybrid electric vehicle with the possibility to plug in. With frequent charging and appropriate driving PHEV may work only on electric power. In the EU *Fit for 55* programme these cars are considered emission-producing vehicles.

cont. Table 1

Electric vehicle (EV)	Electric vehicle
Range extended electric vehicle (REEV)	Apart from an electric motor as the basic drive, it is also equipped with combustion engine. In this type of vehicle combustion engine is used only when energy is needed to charge the battery ensuring electric drive.
Fuel cell electric vehicles (FCEV)	Electric vehicle equipped with fuel cells fed with hydrogen (H_2), taken from a tank fixed in the car and filled on fuel stations.

Source: self-reported data.

Consumer preferences for satisfying mobility needs

Since the second decade of the 21st century, more and more attention has been paid to negative effects of regular combustion engine cars emitting pollution and greenhouse gases. That is why the automotive industry has been looking for innovative, environmentally and socially friendly solutions that would satisfy the need for individual mobility and reduce climate instability. The pace of changes in the automotive industry in China, Europe and USA is increasing each year, due to social pressure and increasingly restrictive administrative regulations introduced or announced by public authorities.

Let us note that research on green transition proves that adaptation of green technologies depends on both internal and external consumer motivation. The former covers personal sense of responsibility for natural environment, while the latter is based mostly on financial incentives, although it can also include external pressure of positive motivation induced by other people [Coad, De Haan, Woersdorfer, 2009]. Research conducted in the first decade of the 21st century showed that electric vehicles are purchased mostly by people declaring higher environmental awareness, and it is often a manifestation of their beliefs [Heffner, Kurani, Turrentine, 2007; Gallagher, Muehlegger, 2011]. These people are also more inclined to use means of transport alternative to a passenger car, such as public transport [Kahn, 2007].

Supply chains in the car industry for many decades have been triggered by consumer demand. That is why consumer demand for electric vehicles is analysed in numerous pieces of research and scientific studies. The main research tool in this case are surveys held in many countries and in different social groups. They provide an insight into consumer preferences, plans of electric vehicle purchase and factors affecting the decisions.

Research from the second decade of the 21st century proves that, when making a decision to buy an electric car, consumers usually pay attention to its technical parameters and expect it to be better than, or at least comparable to those of regular combustion engine cars. A review of 26 studies describing broadly defined preferences pertaining to purchases of alternative-drive vehicles has proven that the financial aspect (i.e. the cost of purchase and maintaining a vehicle) and technical aspects (i.e. the range, charging time, performance) have the biggest influence on the decision to buy an electric car [Liao, 2017]. What is also important is the density of charging station network, which, in the view of potential consumers, improves the usability of battery electric vehicles.

These observations are confirmed by an analysis of results of surveys on European citizens, which indicates that a reduction of BEV price is the main factor that could incline a potential buyer to purchase such a vehicle. The second important parameter is the range of BEV. Availability of charging stations is important for those considering a purchase of an electric vehicle [Cecere, Corrocher, Guerzoni, 2018; Rommel, Sagebiel, 2021]. Research carried out in Switzerland proves that access to private charging points may significantly improve the attractiveness of BEV [Patt, Aplyn, Weyrich, van Vliet, 2019]. It was found that people having their own parking space and potential access to a charging point ensured there are by 50% more eager to buy an electric vehicle than those who leave their car in public space, for example on a street. Moreover, the Swiss research shows that the level of education is correlated with the willingness to buy – the higher the education of a potential buyer, the more interested they are in purchasing an EV. Still, in 2019 less than half of the Swiss were considering a possibility to buy and electric car in the coming years. In order to achieve EU climate goals, EVs should quickly dominate the car market, while even in a society as wealthy as the Swiss, still half of people are not even considering purchasing it. Further research held among Swiss citizens only confirmed this observation [Wicki, Brückmann, Quoss, Bernauer, 2022].

Research on the German market shows that more German consumers are ready to buy bundles comprising an electric car and photovoltaic panels than to buy only EVs [Stauch, 2021].

An interesting field in the research on the shift to EVs is an analysis of contemporary consumers' preferences of various ownership and use models. It is worth to refer to studies which analysed:

a) vehicle purchase
b) battery lease
c) lease of a whole BEV
d) EV sharing (B2C, BEV sharing) [Huang et al., 2021].

The results demonstrate, among other things, a strong impact of demographic factors (income, age, car ownership) on the preferred model of car ownership. For example, it is more common for lower-income social groups to use the car sharing models, while battery lease or car lease models are more attractive for higher-income groups.

The research also highlights substantial differences in the attitude to vehicle parameters and auxiliary infrastructure, depending on the ownership model. For example, availability of public charging stations and time needed to charge a battery is not very important for those who prefer purchase or lease of BEV. These consumers value the possibility to charge the vehicle at home.

Psychological barriers for the purchase of BEV were analysed in Denmark. The researchers proved that one of the main reasons discouraging people from buying a BEV is lack of knowledge on the technology progress in infrastructure, as well as building and running these cars [Thøgersen, Ebsen, 2019].

The reference literature also provides studies on the Polish market. One of the latest pieces of research, held in 2021 by InsightOut Lab in cooperation with Volkswagen, showed that 23% of consumers in Poland are considering purchase of an EV [InsightOut Lab, 2021]. The key factors are environment protection, low BEV maintenance costs, possibility to charge the vehicle at home and complementary benefits, such as free parking in paid parking zones and being allowed to drive on bus lanes. Nevertheless, the potential of buying these cars, especially on the used cars market, is limited because of high purchase cost [Bienias, Kowalska-Pyzalska, Ramsey, 2020]. When forecasting demand for new and used BEVs, the discrepancy between declarations of potential buyers and their actual purchasing decisions should be taken into account.

Evolution of urban mobility system

Urban areas are of key significance for energy and climate transition. On the one hand, they emit the most pollutions, and, on the other hand, they are the most vulnerable to the negative impact of greenhouse gas emission. About 55% of population today live in towns and cities, and by 2050 this rate will grow to 68%, according to UN [UN, 2018]. Progressing urbanization entails also damage of natural environment, which is practically unavoidable [Borck, Tabuchi, 2019]. However, contemporary ideas of urban development, such as the concept *Smart City 3.0*, place more and more emphasis on sustainable development and the quality of their inhabitants' life [Cohen, 2015]. This is also true for the transport sector, which in the EU alone is responsible for 25% of GHG emissions and a range of local problems related to air and environment pollution [EEA, 2020].

It is impossible to achieve EU climate goals defined in the *European Green Deal* without implementing sustainable mobility in cities. A major challenge for modern transport policy is to reduce individual mobility, and due to their specific character (high population density, easy access to infrastructure and ICT technologies), cities are an advantageous area for introducing alternative, often innovative services and means of transport. One of substantial advantages of a city is its multimodality, which is an important element of transport decarbonization. Ensuring access to multiple travel options, also low-emission ones, to transport system users, will enable reduction of carbon footprint of this sector and cities in general. Progressing digitization of the sector translates into the functioning of markets, infrastructure, practices, and preferences of consumers, as well as social and cultural aspects of transport [Geels, Schwanen, Sorrell, Jenkins, Sovacool, 2018]. Also global trends related to growing climate and environmental awareness of generations Y and Z, which have new, different life expectations, make the innovative mobility solutions more popular, whereby owning a car is not an obvious need any more [Bayart, Havet, Bonnel, Bouzouina, 2020].

One of the main innovative aspects of urban transport systems is shared mobility – a service of renting individual vehicles from an operator's fleet [Pistelok, Straub, 2022]. This concept is not new, but since 2000 it has been revived both in research and in the practice of urban transport systems management [Millard-Ball, 2005; Ricci, 2015; Si, Shi, Wu, Chen, Zhao, 2019]. Today shared mobility models are in place for all the major urban means of transport: car sharing, bike sharing, and recently even e-scooter and motor scooter sharing (shared micromobility). These issues are of particular interest to scientists. Research shows that effective shared mobility systems may substantially contribute to decarbonization of urban transport, by, among other things, reduced congestion and emissions, more efficient parking space management and driving down the need to have a car and, in consequence, lower rate of car use [Becker, Ciari, Axhausen, 2017; Li, Zhang, Ding, Ren, 2019; Eren, Uz, 2020]. According to OECD data, mobility based on shared EVs could reduce GHG emission in cities by even 60%.

Another vital trend are changes in urban spatial planning, which for many years has been conditioned by the paradigm of transport infrastructure development. One of the most popular effects of efforts to solve this problem is the concept of "15-minute city". It is a vision of urban space where most daily necessities can be accomplished within a 15-minute journey, preferably by either walking or cycling from residents' homes [Moreno, Allam, Chabaud, Gall, Pratlong, 2021]. The broader aim of the concept is improvement of life quality. Many large agglomerations, such as Paris, Ottawa, Melbourne, and Milan, have already implemented elements of this concept in their development strategies.

Evolution of urban areas and the aforementioned factors affecting them will undoubtedly continue to shape the demand for passenger cars. Modern urban transport policies reduce passenger car usability and raise competitiveness of alternative means of transport. It can be therefore assumed that in the long-term perspective they will also push down the demand for passenger cars, at least in the traditional and most popular model of car ownership.

Climate and energy policy

An issue often discussed on the global forum are the risks brought by growing climate instability. Cooperation of political and economic circles has led to a consensus, pursuant to which the community of the entire planet must stop the emission of GHG, most of all CO_2, caused by combustion of solid, liquid and gas fuels. Provisions of the 2015 Paris Agreement stipulate that the planet must achieve net zero emission of CO_2 by 2050. The measures that have already been put in place by public authorities of all the countries in the world and by business circles are considered to be insufficient. According to the OECD report of 2022, its member countries are still very far from achieving the goal by the deadline [OECD, 2022]. Furthermore, it must be taken into account that other countries are implementing provisions of the Paris climate agreement at various pace. In many countries, also the ones with the biggest population – China and India – public authority has already admitted that the goal will be achieved only after 2050, and in this decade GHG emissions will continue to grow.

In EU-27 Member States are undertaking various efforts to effect the *European Green Deal*. Regardless of different hurdles, such as COVID-19 pandemic and Russia's military invasion on Ukraine, the European business continues its measures taken to modify manufacture and distribution of tangible and non-tangible goods, in order to significantly reduce CO_2 emissions. In the mobility and logistics sector the basic aim is to drive down the consumption of hydrocarbon fuels that are used in combustion engines.

One of the solutions that will allow to achieve the goals of climate policy is energy transition in those fields of transport sector where combustion engines prevail, i.e. in the road, sea and air transport. In the rail transport the process of phasing out combustion engines needs to be finalised. For many decades most of the work has been done there using electric motors.

Energy transition in transport requires a change of drives assembled in new means of transport and replacement of distribution infrastructure based on liquid fuels and gas by electric energy distribution infrastructure.

Implementation of climate policy in the wheel transport covers also passenger cars. Since 2015 public authorities at the EU and national level have been promoting energy transition in the passenger car sector. However, it has been limited to one preferred solution, i.e. combustion engine passenger cars fuelled by petrol or diesel oil, are replaced by battery electric vehicles.

The automotive industry in Europe until the second decade of the 21^{st} century was refraining from implementing new solutions for passenger car drive. In recent years there has been a dramatic shift in the development strategy and production of new battery vehicles has been launched. The aim was to replace combustion engine passenger cars with battery electric vehicles. Because of the long period of shift in passenger car manufacture, which in Europe will last at least until 2035, and their several-years period of exploitation, Europe will probably not manage to withdraw all the cars with combustion engines from traffic by 2050. In 2021 Europe was the second region in the world with the highest number of battery passenger cars sold – 1 050 million. The leader was China, with 1 570 million cars [Paoli, Gül, 2022]. The share of zero-emission vehicles in the total fleet of passenger cars in Europe has not reached 5% yet, although in some countries, such as Norway, the rate is relatively high, at nearly 50%. In 2021 65% of newly registered cars in Norway were zero-emission vehicles [Klesty, 2022].

In the perspective reaching beyond 2030, it is possible to apply other methods than battery passenger vehicles to eliminate CO_2 and other GHG emissions, and, to a large extent, emissions of solid and liquid pollutions. It is still unknown when technologically and commercially mature methods will be in place, but R&D works on hydrogen fuel cell vehicles are worth attention, as well as those fuelled by liquid fuel obtained through synthesis of hydrogen (H_2) and CO_2 from the atmosphere. It is even more reasonable to seek new solutions, since production and exploitation of a battery passenger car is still burdensome for the natural environment. Apart from the environmental issue, there is also the economic aspect – high price of materials and components necessary to make a battery. There are contradictory views, where one refers to the perspective of improving battery production technology and reduction of costs of mass production, and the second assumes shortage of raw materials and growing costs of battery production.

In the light of these findings, it is necessary to consider also a fundamental reservation: energy transition of automobility, consisting in the common use of battery passenger cars, will only bring required effects if electricity for charging the batteries produces zero emissions. Only a few countries in the world have satisfied these conditions so far (e.g. Norway), but none of them is a Member State of EU-27, where energy mix includes both emission-producing and zero-emission technologies. Poland is one of the countries with a high share of emission-producing technologies in its power sector.

Development of passenger car sector in the future

Methods of preparing development scenarios

In the literature devoted to the functioning and development of mobility and logistics sectors many authors consider that in the coming future uncertainty and randomness of these sectors in their functional environment will be rising. Thus, it is suggested to apply the method of development scenarios. This requires taking account of data and results, and their analysis relating to the future (*predetermined factors*), as well as factors that could disrupt development trends observed in the future (*uncertainties*) [Ruciński, Madej, 2014]. To ensure that the processes of preparing each of the scenarios are transparent, it is recommended to systematize factors taken into account in the description of causal relationships between phenomena inside an analysed sector or in its part, and in the surrounding environment. As a rule, six groups of factors are distinguished: social, technology, economic, environmental, policy and legal factors [Kononiuk, 2011]. In this study an additional group is added: disruptive factors. These are phenomena which occur unexpectedly and strongly impact various events and behaviours of stakeholders and their environment, thereby leading to structural changes within a sector [Kaplan, 2019]. Considering the years 2019–2022, we can refer to the famous statement by Henning Vöpel [2020]: “the pandemic is one of these events in history that drives the world to change, and in the future events will be attributed to the way the world was functioning before the pandemic and afterwards”.

For the purposes of this report, a set of factors was prepared (Table 2), which are considered to have a major impact on the course of social and economic processes described in the automobility energy transition scenarios, in the global scale, in Europe, and Poland.

During the work on this report, from May 2022, the impact of these factors was analysed by the team of IIiTM SGH and consulted with industry experts, such as representatives of the Polish Association of Automotive Industry, national and foreign academic centres, as well as Polish specialists on preparing offers of new and used passenger cars.

Based on the analysis of available data and discussions with automotive and power industry experts, and considering results of research conducted by various research entities and polling agencies in Poland and other European countries, the authors of the report found it reasonable to develop three scenarios of energy transition in passenger car sector in Europe and Poland.

Table 2. Factors that impact social and economic processes described in development scenarios

Social	Technology	Economic	Environmental	Policy	Legal	Disruptive
Willingness to live in highly urbanized areas	availability of technologies in individual transport sectors	wealth of the society and economic incentives for individual users	level of education on the significance of the condition of natural environment (including climate)	EU policy of supporting projects on the development of charging stations infrastructure in Europe	legal regulations limiting the use of cars not meeting mandatory standards (< EURO 3)	character of unexpected natural events
Rate and structure of mobility needs	availability of infrastructure of individual modes of transport, power infrastructure (including charging stations) and telecommunications	availability of budgetary funds to finance infrastructure investments	engagement of public authorities (at the European, national, and local level) in measures for environment protection and fight with climate change	EU policy on funding eco-innovation of national economies and businesses	legal regulations banning cars with obsolete petrol engines (< EURO 3) and diesel engines (< EURO 4) to enter city centres	frequency of natural events, strength, and range of their impact
Inclination to use novel solutions to meet mobility needs	pace of new technologies implementation	rate of development of the private business sector	engagement of financial and industry investors in effecting public policies	EU policy on funding EV purchases		character of unexpected man-made events
Readiness to change the way of meeting mobility needs	rate of popularity of renewable energy sources	free flow of capital in goods at the global and regional scale and efficiency of supply chains	effectiveness of implementation administrative restrictions	policy of EU states or cities introducing so-called clean transport zones		strength and range of impact of man-made events
Willingness to formulate and communicate social demands	advancement of digital technologies	popularity and effectiveness of digital technologies	effectiveness of preferred tech solutions and business models			predictability of the pace and range of spreading new technologies announced as "breakthrough"

Source: self-reported data.

Base scenario of energy transition

Since the 2015 Paris agreement, the view that the major challenge for automobility is its inclusion in the transport decarbonization policy has been increasingly common. At the beginning of the third decade of the 21st century, another view has been prevailing, namely that the automotive industry, after its ambivalent approach to whether and how the development strategy should be adjusted, has unequivocally acknowledged the global climate policy. Market incumbents confirmed that they are fully aware of challenges of this policy and that by 2030 or 2035 at the latest Europe, USA, and China – the biggest world markets – will make only zero-emission cars (BEV and FCEV), and production of vehicles with internal combustion engines (ICE) and hybrid motors (HEV and PHEV) will be stopped [McKinsey, 2021]. The story of an American new entrant, Tesla Motors Inc., walks us through this process.

Tesla Motors Inc. and a car as a "smartphone on wheels"

The idea of car production by Tesla Motors Inc., planned in 2006 and implemented two years later in America, from 2019 carried out also in Gigafactory in Shanghai, China, and from 2022 also in Gigafactory close to Berlin, Germany, is based on using an alternative drive. Instead of a combustion engine, applied and improved in the automotive industry for over 100 years, Tesla passenger cars are equipped with an electric motor. This way the solution proposed by Gustav Trouy was revived. In 1881 he constructed a three-wheel vehicle with an electric motor, considered to be the first road vehicle. To feed the motor with electric power, a new generation battery was assembled in the car. Lead-acid batteries, commonly used in the automotive industry, developed in 1850 by Wilhelm J. Sinsteden, are replaced in Tesla cars with lithium-ion batteries. This type of battery was introduced by Sony on the electronics market in 1991.

Tesla's product range, offering the luxurious car Roadster, valued by the end of the 1st decade of the 21st century at USD 109 thousand [Britannica, 2021], is intended for individual car users from the wealthiest group of consumers. The marketing strategy of the innovative car with electric motor and lithium-ion battery (BEV) did not focus on the source of energy as the main feature making the product attractive. It was highlighted that the innovativeness of Tesla vehicles stems mostly from earlier unknown attitude of a vehicle as a networked device, ensuring its driver and passengers new user experience (UX). Promotion campaigns said that Tesla cars are "smartphones on wheels" with features of an autonomous vehicle that release the user from many activities that regular drivers of passenger cars have to do. The message to the customers suggested that using Tesla cars brings new forms of satisfaction, thanks to new digital technologies. It also promised that Tesla makes autonomous vehicles, which cannot be confirmed, as only slightly advanced (*level 2*) solutions are available from the announced level of almost complete automation (*level 4*).

Initially, the success of Tesla Inc. was mostly marketing in nature. The revenues from car sales did not cover their production costs. The situation caused distrust among manufacturers in USA and Western Europe – they started wondering whether shifting their production from ICE cars to BEV would bring any profit. Only at the end of the second decade of the 21st century the volume of Tesla cars production allowed the company to reach break-even point, and report a profit of USD 5.5 billion in its income statement for 2021 [Zandt, 2022].

Source: self-reported data.

The reference to the experience of Tesla Motors Inc. in creating the base scenario is reasonable, but requires one major economic factor to be considered. Both Tesla cars and other BEVs offered by numerous manufacturers, are luxurious cars. The world rating of Best Electric Cars published in 2022 included only a few mid-size class cars (Honda E – third position, Skoda Enyaq iV – sixth position, Hyundai Kona Electric – eighth position, BMW i3 – ninth position, Mini Electric – twelfth position, VW ID.3 – thirteenth position, Peugeot e-208 – nineteenth position) and only two economy class cars (Renault Zoe – seventeenth position, Fiat 500 – twentieth position) [Top Gear, 2022]. All BEV models in the rating are offered at a price which is unaffordable for most consumers. Such barriers are proven by the fact that in Europe, including Poland, new BEVs, PHEVs, and few FCEVs are bought relatively often to expand or replace corporate fleet. They are hardly ever purchased by households.

The situation on the Polish market is particular. Each European country has different social and economic conditions with prevailing car user behaviours. In Poland majority of cars are used for more than 10 years, which makes the average age of the entire passenger car fleet 15.5 years by the end of 2021 [Gis, 2022]. It should be highlighted that social and economic factors affecting the supply and demand side of the automotive market incline people to buy used cars imported from the Western Europe. As a result, relatively few new cars sold by local dealers are registered in Poland. This phenomenon has, and will continue to have an influence on the pace of structural changes in all the car fleet. There are, and will be relatively few zero-emission cars, although the share of BEVs in vehicles imported to Poland will be growing gradually, which will be a consequence of their increasing number on the secondary market in the Western Europe.

The base scenario, illustrated by data in Table 3 on the Polish market, covers the number and structure of newly registered vehicles in 2021 and projected figures for 2022. It is expected that the sales of zero-emission passenger cars, such as BEV and PHEV, will rise (+60.7% compared to 2021), as well as low-emission vehicles, or HEV and *soft*-HEV (+7.7%). The rate of projected changes is fast, although in both these segments absolute number of registrations in 2021 remained low.

In the ICE segment, covering cars fuelled by petrol and diesel oil, as well as LPG, which is vital for shaping the market, a relatively big decrease is projected (–23.7%). To some extent it may be compensated by higher sales rate of hybrid vehicles. CO_2 emission parameters in cars having both combustion engines and electric motors are lower than for ICE, but the emission reduction is not sufficient to bring automobility closer to the climate policy goal of net zero emissions.

The segment of other vehicles, equipped with fuel cells feeding an electric motor (FCEV) is not included in the quantitative analysis, because by 2030 no increase in the share of these vehicles in total sales on the Polish market is predicted.

In the base scenario the analysis skips also the possibility to replace traditional fuels from processed crude oil by other liquid and gas fuels. In the 2030 perspective no large-scale introduction of synthetic fuels is predicted to replace petrol and diesel oil, produced with the use of "green hydrogen" and "green methane" produced by plastics recycling.

Table 3. Number and structure of newly registered vehicles in Poland in 2021 and projections for 2022

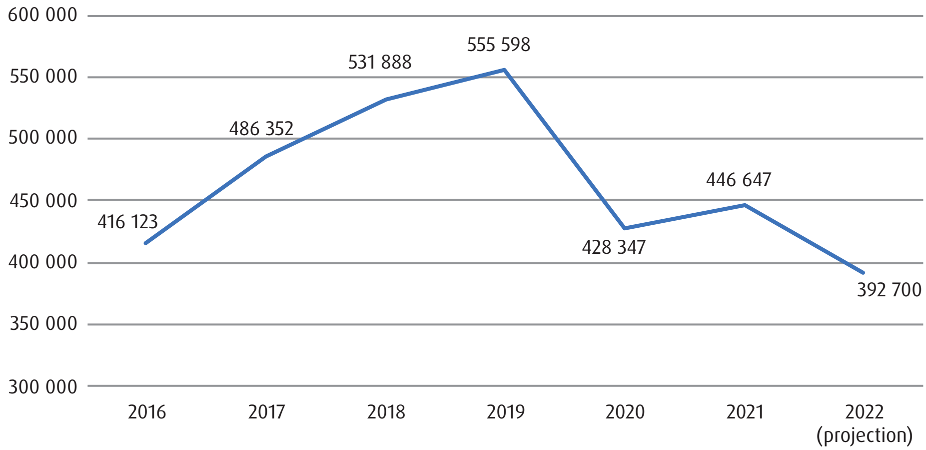
Year	New registrations in Poland	Number of vehicles	Share of BEV and PHEV (%)	Rate of changes y/y (%)
		Base scenario		
Reported data				
2021	ICE/LPG	307,996	69.0	
	HEV/*soft*-HEV	122,176	27.4	
	BEV/PHEV	16,355	3.7	
	Total	446,647	100.0	
Projected data				
2022	ICE/LPG	234,878	59.8	**−23.7**
	HEV/*soft*-HEV	131,574	33.5	7.7
	BEV/PHEV	26,280	6.7	60.7
	Total	392,732	**100.0**	**−12.1**

Source: self-reported data based on the data of PZPM.

The sales rate of new cars in Poland fell in 2020. In next years, no recovery of the 2019 record rate is predicted. The changes in sales rates in 2016–2021 and projection for 2022 are illustrated by data on Figure 1.

The base scenario should take into account the fact that in 2020, for the first time since the end of World War II the European automotive industry had to confront supply barriers and was not able to deliver planned development projects on time, including projects covering broader application of digital technologies in new models of ICE, HEV/*soft*-HEV and BEV/PHEV. The same hurdles occurred in 2021, and events that took place in the first five months of 2022 indicate that manufacturers still cannot offer as many and as structured products as expected by customers. There is a risk that the changing geopolitical and pandemic situation may exacerbate the unfavourable conditions later in 2022, or that they can even extend to 2023. Past experience shows that with limited production capacity the European industry prefers such a structure of produced vehicles, which allows for higher sales profitability. An example may be the measures applied by the biggest European car maker, Volkswagen Group. In 2021, when materials were scarce, and there were not enough imported microchips, VW made endeavours to maintain the volume of production of Porsche cars, followed by Audi, while the manufacture of other, less profitable brands was reduced. The strategy was continued in 2022 [Bericht, 2022]. Troubles experienced by the German car maker in 2020–2022 will be also experienced by the Polish market in 2025–2030, when the imports of used car will fall, since their supply on the secondary market in Germany and the rest of Western Europe will drop. This perspective should be perceived as a technology factor, which initially will affect the supply side of the European market of new cars, and next it is going to affect the demand side of the Polish market segment of used cars.

Figure 1. Changes in the numbers of newly registered passenger cars in Poland in 2016–2021 and projection for 2022



Source: self-reported data based on the data of PZPM.

The base scenario includes the general trend of growing share of zero-emission cars in the total number of newly registered vehicles. Estimates for new registrations in various market segments in the years 2023–2025 and 2030 in Poland are presented in Table 4. It covers two options of possible development of the number of newly registered passenger cars in Poland. Option I refers to estimates excluding increasing restrictions on new cars manufacture. Option II, covering projections for the years 2023–2025, refers to reduced product range that should not persist for many years, so for the year 2030 the same number of newly registered passenger cars as in Option I was assumed.

Table 4. Estimates and structure of newly registered passenger cars in Poland in the years 2023–2025 and 2030.

		Option I		Option II		
Year	New registrations in Poland	Total number	Share of BEV and PHEV (%)	Total number	Share of BEV and PHEV (%)	Correction factor in Option II (%)
		Base scenario		Base scenario		
2023	ICE/LPG	431,650	89.0	388,485	89.0	
	HEV/*soft*-HEV					
	BEV/PHEV	53,350	11.0	48,015	11.0	
	Total	485,000		436,500		**−10**
2024	ICE/LPG	429,250	85.0	394,910	85.0	
	HEV/*soft*-HEV					
	BEV/PHEV	75,750	15.0	69,690	15.0	
	Total	505,000		464,600		**−8**
2025	ICE/LPG	416,000	80.0	395,200	80.0	
	HEV/*soft*-HEV					
	BEV/PHEV	104,000	20.0	98,800	20.0	
	Total	520,000		494,000		**−5**
...						
2030	ICE/LPG	406,000	70.0	406,000	70.0	
	HEV/*soft*-HEV					
	BEV/PHEV	174,000	30.0	174,000	30.0	
	Total	580,000		580,000		

Note: the table presents option I of the base scenario and option II, which includes hypothetical effects of smaller car supply in Europe due to technology barrier and problems with materials.

Source: self-reported data based on the data of PZPM.

The base scenario assumes gradual increase in the fleet of zero-emission passenger cars (BEVs) from approximately 40 thousand by the end of February 2022, to about 53 thousand by the end of 2023, and to as much as about 174 thousand in 2030. It can be assumed that by the end of the third decade of the 21st century around one million zero-emission passenger cars will be used in Poland. If the entire fleet at that point in the future is around 20 million vehicles, which is slightly more than by the end of 2021, when it was around 19 million, the share of BEVs and (and PHEVs) will reach approximately 5%.

In the scenario projecting growth of zero-emission plug-in electric vehicles from 40 thousand to 1 million, it must be explained whether the development of public charging stations is a technology factor of critical significance. Research conducted in Germany in 2021 and the second quarter of 2022 proves that as much as 75% of BEV/PHEV users declare a possibility to charge batteries without using public charging stations. That is because many people there have private charging stations at home (in a garage or on a dedicated parking space) or at work (on a dedicated parking space). Considering that in Poland passenger BEVs are used by wealthy people or households with opportunities similar to those of BEV users in Germany, it can be assumed that access to public charging stations is important for two groups: residents of apartment buildings (who account for about 25% of all BEV/PHEV users), and car users who drive longer distances than the range of a battery electric vehicle. Meeting the needs of these two groups is a challenge in Poland and other European countries with changeable climate conditions, where for many days or even weeks the air temperature may be below zero and heavy frost may occur (sometimes below –25°C). When the temperature falls below zero, the battery capacity falls so much that it becomes necessary to charge it every several hours of standstill, and after the distance of 100 km or even less.

The influence of the technology factor is therefore critical from the perspective of increasing the number of zero-emission battery car users. The base scenario assumes that by 2030 the network of public charging stations will be appropriately extended. This means that when electromobility ecosystem is being developed, power infrastructure barriers are not exposed, both in respect of production (and supplies) of electricity in peak hours (in the 24-hour cycle), and possibilities of sending power to public charging stations connected to local electricity grids. At this point it is necessary to refer to electricity expert opinions, indicating numerous barriers hindering the achievement of required development of private and public charging stations for BEVs. The experts also express doubts whether it will be possible to use a significant portion of energy produced by prosumers to charge batteries. For most of them have photovoltaic technologies in place, which produce electric power during day sunlight, while passenger car batteries are plugged in to charge during the night.

Not including the power infrastructure as a barrier for Polish electromobility by 2030 in the base scenario will not make it possible to eliminate the negative impact of this factor on the social perception of energy transition in the second half of the fourth decade of the 21st century.

Scenario of limited approval for electric passenger cars (*BEV is not cool*)

The analysis framework for the scenario of limited approval for electric passenger cars is based on the idea of “balanced narrative”, which comprises three trends of discussion on popularising zero-emission vehicles:

- social and economic trend deriving from public policy defined in the 2015 Paris Agreement;
- technology and economic trend defined by the automotive industry promoting BEVs;
- multi-threaded discussion on social and consumer-related aspects.

Basic arguments in discussions carried out for each of these trends are presented in Table 5.

Table 5. Trends of "balanced narrative" referring to promotion and popularization of zero-emission vehicles

Issue	Social an economic trend	Technology and economic trend	Social and consumer trend
Reduced impact on the natural environment and counteracting the risk of unstable climate conditions threatening social life	very progressive green policy, extended by aspects of climate policy in the EU and some Member States; selective policy in Poland, certain measures are often forced by EU regulations	producers of the automotive industry must adjust to new conditions, such as restrictions in the form of administrative bans or economic triggers; in effect they will include BEVs in their product range	green activists conduct actions to persuade the public authorities to introduce under their progressive public policies various regulations limiting car traffic
Building economic governance comprising mobility systems	after the period of promoting automobility (from 1920 s in USA and 1950 in the Western Europe), at the end of the 20th and beginning of the 21st century restrictions on the use of cars were gradually introduced, especially on highly urbanized areas	after the oil crisis (1973–1974) extending the range of cars consuming below 10 l of fuel per 100 km; at the beginning of the 21st century hybrid cars were popularized, and Tesla began production of BEVs; Uber project is an innovation that makes car ownership less popular	communities in large cities more and more appreciate public transport and micromobility solutions (e-scooters in sharing economy) and encourage public authorities to extend its range of services
Popularization of zero-emission vehicles (BEV)	public authority supports industry in various ways to accelerate growth in BEV production	automotive industry broadens its competencies by battery production technologies and development of BEV steering software	as a result of a focus on market research on BEV users' behaviour, public opinion receives only selected arguments about the approval or disapproval of BEVs by large groups of society

Source: self-reported data.

In the *BEV is not cool* scenario the following issues deserve particular attention.

First, it is debatable whether public authority's strategy of promoting only BEVs is reasonable. It disregards alternative solutions, although it is not certain whether the goal of public environmental and climate policy can be reached with lower expenses, by promoting only BEVs. The doubts concern mostly total expenses to be incurred if demand for access to public charging stations starts to increase, and correct evaluation, in line with environmental and climate criteria, of BEV's advantage over ICE across the lifecycle of these vehicles.

Second, it is uncertain whether the industry in Europe will reach sufficient capacity to manufacture required number of batteries by 2030. Many experts point out to limited possibilities of obtaining raw materials and components, also from regions outside the European continent. In the global geopolitical environment, which is very volatile in the third decade of the 21st century, administrative and logistic barriers may become even more significant and obstruct delivery of larger supplies.

Third, there are no economic analyses allowing to establish to what extend broader consumer groups will have appropriate financial resources and technical conditions (such as access to private charging station) to replace the use of an old ICE car by a new or used BEV. The economic barrier may discourage households from purchasing BEVs for many years, which will delay popularization of these vehicles in Poland beyond 2030.

Fourth, there are no data on the situation where BEVs would be used in Europe by more than 20% of all users of passenger cars. Gradually, knowledge has been collected, going beyond already known experiences with BEVs in the market and social niche. This gap, however, has not been commented in media, which has also limited the "balanced narrative". We are therefore facing a certain filter bubble, where only views unequivocally promoting BEVs are presented, and reservations about their benefits are disregarded or poorly substantiated. The bubble is in some respect created by various groups of automotive market stakeholder groups, who, intentionally or not, avoid the analysis of controversial issues. Particularly significant here is the role of corporate discipline, which requires from numerous specialists working for the automotive industry to refrain from expressing their views and doubts in public.

One of the signs indicating that the electromobility narrative is extended onto new threads, is an article in *Die Welt* from 2022, dedicated to various conditions that weaken the attractiveness of BEV/PHEV use. Table 6 presents factors that push down or curb the purchase and use of BEVs/PHEVs. Table 7 describes conditions that consumers want to be met for them to take the decision on replacing an ICE car by a zero-emission passenger vehicle.

Table 6. List of factors that push down or curb the purchase and use of BEVs/PHEVs

Barrier	Share of answers among the interviewed (%)	Comments
Limited access to public charging stations	84	75% of respondents declare that it is possible to install a private charging station at their house
Excessively high prices of new cars	71	

cont. Table 6

Barrier	Share of answers among the interviewed (%)	Comments
Insufficient range of a vehicle before battery charging	71	according to research made by Deutsche Automobil Treuhand (DAT), average distance covered per year by a passenger car is 14 thousand km, which is around 40 km a day; consequently, the range of a battery electric vehicle should suffice, but the duration of battery charging may be burdensome
The duration of battery charging is too long	70	
Uncertainty about the prices of used BEVs/PHEVs	unknown	buying BEVs/PHEVs that will be available on the secondary market in 2025 and later comes with the risk of obsolescence, i.e. vehicles manufactured in 2021–2022 will be considered less attractive and "old generation"

Note: the table presents results of a survey published in February 2022 by the German Center Automotive Research (CAR), based on 2200 responses.

Source: self-reported data based on Zwick [2022].

Table 7. Declared readiness to buy BEVs/PHEVs among consumers in Germany in 2021 and a list of conditions conducive to such decision

Responders' position	Share of positive responses	Comments
Readiness to buy BEV	25%	survey made among car users
Readiness to buy PHEV	26%	survey made among car users
Readiness to buy BEV/PHEV not earlier than in 2026	about 30% of those declaring readiness to buy BEV/PHEV	it is expected that after 2025 a new generation of BEVs/PHEVs will be available, so it is better to wait with replacing ICE by BEV/PHEV
Attractiveness of flexible forms of long-term financing available for BEV/PHEV users without the need to buy a new car – so-called Auto Abo model	72% respondents from the group of potential BEV/PHEV buyers declares being interested in lease and long-term rental; in 2021 in Germany 53 thousand agreements were signed, the terms of which were from one months to two years (with the general number of newly registered cars of 2.62 million); it is estimated that by 2030 the number of Auto Abo users will grow to 1 million	possibility to avoid the risk of loss with further sale of the vehicle inclines drivers to use BEV/PHEV without purchasing it; the issue of risk valuation by the operator (lessor) is still unsure, as well as its impact on the monthly payments and their relation to the price paid for the car purchase.

Source: self-reported data based on Zwick [2022].

The scenario of limited approval for electric passenger cars takes into account estimates according to which the share of BEVs/PHEVs in the number newly registered cars in Poland in 2023–2025 and 2030 is reduced. The data for this scenario, juxtaposed with those for the base scenario are presented in Table 8.

The more BEVs are used, the faster should proceed the modernization of tech infrastructure and pre-sales service stations. Experiences of other countries, including Scandinavia, show that BEV users do not receive satisfactory services [Bórawski, Bełdycka-Bórawska, Żak, Koszela, 2022]. If this opinion spreads, it may become another factor driving down consumers' willingness to buy zero-emission vehicles.

Table 8. Estimates and structure of newly registered passenger cars in Poland in the years 2023–2025 and 2030.

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Newly registered cars in Poland</th><th>Total number</th><th>Share of BEV and PHEV (%)</th><th>Total number</th><th>Share of BEV and PHEV (%)</th><th rowspan="2">Correction factor (%)</th></tr>
<tr><th colspan="2">Base scenario</th><th colspan="2">Scenario of limited approval for electric passenger cars (BEV is not cool)</th></tr>
<tr><td rowspan="4">2023</td><td>ICE/LPG</td><td rowspan="2">431,650</td><td rowspan="2">89.0</td><td rowspan="2">436,985</td><td rowspan="2">90.1</td><td></td></tr>
<tr><td>HEV/soft-HEV</td><td></td></tr>
<tr><td>BEV/PHEV</td><td>53,350</td><td>11.0</td><td>48,015</td><td>9.9</td><td>−10</td></tr>
<tr><td>Total</td><td>485,000</td><td></td><td>485,000</td><td></td><td></td></tr>
<tr><td rowspan="4">2024</td><td>ICE/LPG</td><td rowspan="2">429,250</td><td rowspan="2">85.0</td><td rowspan="2">444,400</td><td rowspan="2">88.0</td><td></td></tr>
<tr><td>HEV/soft-HEV</td><td></td></tr>
<tr><td>BEV/PHEV</td><td>75,750</td><td>15.0</td><td>60,600</td><td>12.0</td><td>−20</td></tr>
<tr><td>Total</td><td>505,000</td><td></td><td>505,000</td><td></td><td></td></tr>
<tr><td rowspan="4">2025</td><td>ICE/LPG</td><td rowspan="2">416,000</td><td rowspan="2">80.0</td><td rowspan="2">447,200</td><td rowspan="2">86.0</td><td></td></tr>
<tr><td>HEV/soft-HEV</td><td></td></tr>
<tr><td>BEV/PHEV</td><td>104,000</td><td>20.0</td><td>72,800</td><td>14.0</td><td>−30</td></tr>
<tr><td>Total</td><td>520,000</td><td></td><td>520,000</td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">2030</td><td>ICE/LPG</td><td rowspan="2">406,000</td><td rowspan="2">70.0</td><td rowspan="2">466,900</td><td rowspan="2">80.5</td><td></td></tr>
<tr><td>HEV/soft-HEV</td><td></td></tr>
<tr><td>BEV/PHEV</td><td>174,000</td><td>30.0</td><td>113,100</td><td>19.5</td><td>−35</td></tr>
<tr><td>Total</td><td>580,000</td><td></td><td>580,000</td><td></td><td></td></tr>
</table>

Note: the table presents the scenario of limited approval for electric passenger cars, compared with the base scenario.
Source: self-reported data.

In this scenario consumers in future years will be more aware of inconvenience connected with BEV use. In Poland this will bring decrease in growth rate of sales of both new and used models. The number of BEVs and PHEVs on Polish roads will therefore grow from around 40 thousand at the beginning of 2022 to almost 700 thousand by the end of 2030. With slower growth of their share in the total fleet, the increase in the share of ICE vehicles will also be slower, accordingly. It is also expected that the network of public charging stations will develop at a slower rate. In consequence, the pressure on modernization of power grid will lose strength, and investments in installation of charging station from public funds will be lower.

Scenario of decline in supply and demand for new passenger cars (*lower welfare scenario*)

The major premise for the third scenario is the current economic situation in the world and consequential risk of significant decline in consumption rate in Europe. The growing threat of lowering real wages in Europe is shown by, among other things, data from Germany[1]. In the second quarter of 2022 most automotive experts predicted that in the following months automotive industry will probably overcome the existing barriers and will recover its potential of manufacturing a number of car sufficient to meet demand, while maintaining altered product range, connected with a share of higher-class models relatively bigger than in the previous years. At the same time there are many premises suggesting that middle- and lower- income consumers will have significantly smaller available income, and in consequence will have to delay their purchases of new cars by a few years. This can bring a drop in demand for new vehicles in general, although demand for EV product range targeted at the wealthiest consumers may be maintained at the current level or even grow.

A key element in this scenario the currently observed record high rate of inflation, combined with poor GDP growth. Eurostat has informed that in March 2022 HICP[2] in the EU was 7.8%, in Euro zone it was 7.4% – the highest rate for 20 years. Inflation leaders in the EU are Baltic states: Lithuania with its March inflation rate of 15.6% and Estonia with slightly lower rate of 14.8%. In the Czech Republic inflation rate was 11.9%, in the Netherlands 11.7% and in Latvia 11.5%. Poland, with its 10.2% had one of the highest rates, but it was far behind the podium, which it occupied still in December 2021. Even in countries with the lowest HICP (Malta – 4.5%, France – 5.1%), the growth pace was twice faster than the official inflation target of the European Central Bank, which is 2%. It was accompanied by economic slowdown that begun with Covid lockdowns. When in 2021, due to European funds launched to restore the EU, it seemed that the European economy will soon bounce back and the economic growth will be recovered, on 24 February 2022 Russia attacked Ukraine. The war in Ukraine intensified the price rise for raw materials, energy, and food; many

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1 In Germany the drop in real wages was –1.1% in 2020, as a consequence of wage reduction during lockdown introduced in the first waves of the COVID-19 pandemic. In 2020 it was almost negligible (–0,1%), but it increased in the first quarter of 2022 to –1.8%. In the light of incomplete data it can be assessed that the decline in real wages in Poland in 2020–2022 will be much deeper than in Germany.

2 Harmonised Index of Consumer Prices (HICP) are computed by Member States according to uniform methodology of the European Union. The basis of calculation of HICP for Poland is:

- an observation of changes in prices of representatives of consumer goods and services;
- the weight system based on the structure of individual consumption expenditure in the households sector with national accounts statistics from two years ago.

economists started to warn against stagflation, or high inflation with simultaneous stagnation of economic growth.

Stagflation may, but does not have to occur. It is a negative scenario reminiscent of the situation from the 1970 s. Some of the factors that induced it are most of all oil crises and rising oil prices. Some economists argue, however, that they were not as important, as it is suggested. They claim that the stagflation was caused mainly by inappropriate monetary policy [Barsky, Kilian, 2004] and low labour force productivity that did not manage to keep up with wage growth, thus triggering wage-price spiral.

Marek Garbicz, in an interview in late April 2022 said that the stagflation scenario cannot be excluded. He argues that, first, the restrictive monetary policy aimed at pushing down inflation, and second, intensifying uncertainty and investors' risk aversion may impede investments and restrain the flow of working capital. The economist highlighted that in the last years in Poland the rate of growth of work efficiency was keeping up with the growth of wages, so there was no threat of a wage-price spiral. Increase in the inflation rate in the second quarter of 2022 may be an impulse that would raise the risk. In the scenario of lower demand for (and thus supply of) passenger cars the estimated number of newly registered vehicles in Poland in the years 2023–2025 is reduced, with simultaneous increase for 2030. It is based on the assumption that the stagflation will start to recede in the second half of the third decade of the 21st century. If in the years 2023–2025, and maybe also in the two or three following years fewer new vehicles would come to the Polish market, by the end of this decade demand may pick up. It will be probably fully satisfied even if producers' problems with extending product range persist. Data pertaining to the scenario of decline in demand for and supply of passenger cars are presented in Table 9.

Table 9. Estimates and structure of newly registered passenger cars in Poland in the years 2023–2025 and 2030.

Year	Newly registered cars in Poland	Total number	Share of BEV and PHEV (%)	Total number	Share of BEV and PHEV (%)	Correction factor (%)
		Base scenario		Scenario of decline in supply and demand (*lower welfare*)		
2023	ICE/LPG	431,650	89.0	388,485	89.0	
	HEV/*soft*-HEV					
	BEV/PHEV	53,350	11.0	48,015	11.0	
	Total	485,000		436,500		**−10**
2024	ICE/LPG	429,250	85.0	364,863	85.0	
	HEV/*soft*-HEV					
	BEV/PHEV	75,750	15.0	64,388	15.0	
	Total	505,000		429,250		**−15**

cont. Table 9

Year	Newly registered cars in Poland	Total number	Share of BEV and PHEV (%)	Total number	Share of BEV and PHEV (%)	Correction factor (%)
		Base scenario		Scenario of decline in supply and demand (*lower welfare*)		
2025	ICE/LPG	416,000	80.0	374,400	80.0	
	HEV/*soft*-HEV					
	BEV/PHEV	104,000	20.0	93,600	20.0	
	Total	520,000		468,000		**–10**
...						
2030	ICE/LPG	406,000	70.0	487,200	70.0	
	HEV/*soft*-HEV					
	BEV/PHEV	174,000	30.0	208,800	30.0	
	Total	580,000		696,000		+20

Note: the table presents the scenario of decline in supply and demand for passenger cars, compared with the base scenario.

Source: self-reported data.

According to this scenario, the number and share of BEVs and PHEVs in the total fleet by the end of 2030 will be conditioned by the behaviour of ICE car users in this decade. On the one hand, administrative restrictions of access to city centres for ICE vehicles, and absolute and relative increase in their maintenance costs on the other hand, may cause that much more of these cars will be withdrawn from use in the second half of the decade that before 2020. The scenario assumes that by the end of 2030in Poland there will be about 800 thousand BEVs and PHEVs, while the entire fleet will be reduced by about 2 million vehicles, down to about 18 million. The share of zero-emission vehicles will be around 4.5%.

Calculation of potential effects of energy transition according to the base scenario

The three presented scenarios of energy transition in automobility sector enable us to make comparative analyses. Table 10 comprises data on the number of zero-emission vehicles and other car groups in Poland in 2030.

The model assuming the most economic use of secondary energy commodities in automobility makes it possible to establish energy consumption. For BEVs/PHEVs it is 16 kWh of electrical energy per 100 km of distance covered, for the remaining types of vehicles it is 5 litres of diesel oil. Applying a conversion rate of energy content for each of these energy commodities provides estimated energy consumed by the total fleet of passenger cars and by individual vehicle groups (Table 11).

Table 10. Number of zero-emission vehicles (BEVs/PHEVs) and other passenger cars in Poland by the end of 2021 and estimates for the three scenarios for 2030

	Number of BEVs/PHEVs (in millions)		
	Base scenario (option I)	*BEV is not cool*	*Lower welfare*
2021	0.08		
2030	1.00	0.70	0.80
	Number of other cars (in millions)		
	Base scenario (option I)	*BEV is not cool*	*Lower welfare*
2021	19.00		
2030	19.00	19.30	17.20

Source: self-reported data.

Table 11. Hypothetical annual consumption of electrical energy and diesel oil by passenger cars – estimates for 2022 and three scenarios for 2030

	Annual consumption of electrical energy by BEVs/PHEVs (kWh)		
	Base scenario (option I)	*BEV is not cool*	*Lower welfare*
2021	179,200,000		
2030	2,240,000,000	1,568,000,000	1,792,000,000
	Annual consumption of diesel oil by other vehicles (t)		
	Base scenario (option I)	*BEV is not cool*	*Lower welfare*
2021	1 130 500 000		
2030	1 130 500 000	1 148 350 000	1 023 400 000

Source: self-reported data.

Data presented in Table 11 allow for the following analysis of potential climate effects, which are achievable due to the first phase of energy transition in automobility in Poland by 2030.

In the base scenario growth of the number of BEVs from 40 thousand (and additionally 40 thousand PHEVs) to 1 million will cause that the number of other passenger cars will not increase by the same number, since a growth of the total fleet from 19 million cars with average distance covered of 14 thousand km to 20 million cars, will happen due to maintaining the number of other cars, and the total number of vehicles will grow only in the non-emission group. In the base scenario CO_2 emission in 2030 will be the same as in 2022, assuming that non-emission vehicles will run only on energy produced by RES (which is not possible to achieve in practice). Hypothetical reduction of annual CO_2 emission in 2030 would mean elimination of consumption of 700 million litres (i.e. 59.5 tonnes) of diesel oil. With emissions volume of 2.6 kg of

CO_2 per 1 litre of diesel oil, annual emissions can be reduced by 1.82 million tonnes of CO_2. in the base scenario. If the fleet in Poland in 2030 increased to 20 million vehicles and covered only ICE cars, that is excluding non-emission vehicles, hypothetical volume of emissions would reach 36.4 million tonnes of CO_2. A reduction in CO_2 emissions due to introduction of 1 million zero-emission vehicles would therefore hypothetically decrease CO_2 emissions by passenger cars in Poland by 5% in 2030.

It is difficult to establish the economic value of this effect in PLN.

Introducing a million zero-emission BEVs on the Polish market by the end of 2030 would require investment outlays for new car purchases. Assuming an average value of a vehicle is PLN 200 thousand, households and enterprises buying passenger cars for their business fleet would have to expend over PLN 190 billion within eight years. The base scenario forecasts 174 thousand new registrations of BEVs/PHEVs n 2030. This year (according to prices of 2022) expenditures for BEVs/PHEVs would have amounted to PLN 34.8 billion. in 2021 around PLN 3.6 billion were spent for this purpose.

While discussing energy transition of automobility, which is already happening in Europe and in Poland, it should be stressed that capital-intensive investments and high maintenance costs of zero-emission passenger cars do not cover the criterion of economic effectiveness, which is an element of microeconomic calculus. This is a consequence of lack of information about the effects of economic processes and consumer activities. Such an analysis will be possible in a few years, when data describing the closing of the first stage of the efforts will be available.

Summary

Deliberations presented above give a basis to formulate some important conclusions and recommendations for the public authority and automotive industry.

1) The goals of public policies – environmental policy (aimed at reducing the burden for the natural environment created by pollution, noise and car-induced vibrations) and climate and energy policy (aimed at reduction of greenhouse gases, including most of all CO_2, produced by combustion engines or furnaces used in power plants to produce power that feeds batteries of electric vehicles) will be achieved in Poland the fastest if the process of introducing new generation cars and withdrawing old cars with large distance covered will be accelerated. Public authorities should encourage consumers to buy new cars that meet higher environmental standards than older vehicles. The support will be particularly necessary if, because of economic decline, consumers will be less inclined to buy new vehicles, both zero-emission ones (BEV and FCEV) and those producing emis-

sions (ICE, PHEV and HEV). To support this process, it is also required to drive down the imports of used cars.

2) Promotion of BEVs is reasonable only in certain cases. As long as batteries in these cars are powered by electrical energy from sources producing emissions, which prevail and will continue to prevail in Poland in the following years, replacing emission-producing BEVs will hardly contribute to CO_2 reduction in passenger car sector. There is no reason to accelerate the development of public charging stations in Poland at least by 2030, because anyway they distribute electrical power produced with high-emission technologies.
3) It is particularly reasonable to promote purchase and use of battery electric vehicles, if they are to be used by households having their own zero-emission source of electrical energy (photovoltaic panels) and equipment for energy storage.
4) Public authority at the national level should diversify public policy on the development of automobility sector in large cities and other regions of the country. Local authorities in large cities should have considerable freedom in creating the system of mobility services for their inhabitants and visitors. Public policy aimed at reducing passenger cars producing emissions (ICE, HEV and PHEV) cannot lead to greater transport exclusion of people living in economically less developed regions with limited access to organised transport services.
5) Passenger car makers and their dealers should be encouraged by administrative measures and commercially rewarded by public authorities to provide maintenance services for cars used for many years, in order to keep them in a good technical condition, necessary to eliminate excessive pollution and CO_2.

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TRANSPOSITION OF SUPPLIES AND FLOWS OF THE PETROCHEMICAL INDUSTRY IN EUROPE – THE STATE AND RESOURCE CONDITIONS OF SUSTAINABLE SUPPLY CHAINS AND CIRCULAR ECONOMY

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Abstract

The main objective of the study is to indicate changes and trends in the European flow of petrochemical products, including plastics, caused by disruptions in global supply chains, with particular emphasis on the requirements of sustainable development and circular economy (CE). The first part of the study addresses recovery of the demand for plastics in the world and in Europe, including the countries of Central and Eastern Europe, and discusses related trends in plastics supply chains. Further the study highlights problems with European supply chains of plastics, as well as risks and needs related to building resilience of these supply chains by changing the force of flow of goods to and from Central and Eastern European markets, thereby setting conditions for closed loop as one of the key factors of reconfiguration. Finally, determinants stimulating the closed circulation of supply chains are presented, based on circular economy requirements. The article also discusses conditions of stabilizing flows of plastics in accordance with sustainable development goals and within the limits of responsibility defined by the principles of circular economy.

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Volatility of petrochemical industry in Europe, caused by instability and changes induced by the global COVID-19 pandemic, exposes a need for diversification of both supply sources and processing of the petrochemical raw materials to reclaim, transform and feed them back into circulation. Global and European petrochemical trade trends of circularity, covering reprocessing (including recycling) and reconfiguration of resource life cycle, demonstrate the need to find new, effective streams of petrochemical products, including plastics.

The main objective of the study is to identify changes and trends in the European flow of petrochemical products, such as plastics, caused by disruptions in global supply chains, with particular emphasis on the requirements of sustainable development and circular economy (CE).

Diversification of resources and redistribution of petrochemical products by reconfiguration of plastics supply chains, through changing forces of supply and distribution to Central and Eastern Europe (CEE) and adapting plastics supply chains to the implementation of CE goals, is a result of modifications and uncertainty in global supply chains.

In line with sustainable development trends contemporary structures of European supply chains should be aiming at reaching closed and circular cycle of resource flow in the economy, including also the European petrochemical industry. In the closed cycle of processing, flows of petrochemical products, especially plastics, require a diagnosis of the current situation of market uncertainty caused by the COVID-19 pandemic. Moreover, trends and long-term changes of the market forces and supply chains links should be defined.

Trends in the development of plastics market in the European Union

Description and perspectives of petrochemical industry development

Petrochemical industry obtains raw materials mainly from refining crude oil and processing natural gas. It further transforms them into valuable products, using various technologies and chemical processes [Clews, 2016]. This sector makes a broad range of chemical products (chemicals), indispensable for manufacturing materials such as synthetic rubber, solvents, fertilizers, pharmaceuticals, additives, explosives and glues. Chemicals are very important for almost all spheres of contemporary society and are a basis of growth of different sectors. They are used in cars, packaging, household appliances, medical equipment, paints, clothes and construction materials, just to name a few typical applications. Moreover, petrochemical industry is considerably innovative due to new technologies and possibilities of processing various kinds of raw materials.

Historically the sector evolved from technology innovations in developed industrialised economies. Until the last quarter of the 20^{th} century manufacture of petrochemicals was concentrated in the Western Europe, United States and Japan. In the last few decades, however, the production has been strongly developing in regions with competitive raw material prices, i.e. Middle East and Asia. The competitive landscape of the industry has changed as a result of extensive production capacity and large-scale use of state-of-the-art technology, combined with availability of cheap raw materials. Many of the older plants using more expensive raw materials were not able to compete effectively, particularly on the established, mature European markets, which has led to their closure [Clews, 2016].

Today, it can be observed that simple production of liquid fuels from crude oil is losing significance and being replaced by technologically advanced petrochemicals, which in the coming years will be a trigger for investments in new projects. Pursuant to GlobalData production capacity of petrochemicals will rise by more than 40%

globally, compared to 2020. The largest investments will be made by China, which will account for as much as 29% new global petrochemical power. Further positions on the list of planned investments will be held by India, Iran, Russia and USA, with no European Union states among the first ten [Furman, 2021]. In Poland the sector will be developing dynamically, with investments of major enterprises like PKN Orlen (construction of Olefin III complex), Anwil owned by PKN Orlen (construction of a third production line for production of nitrogen fertilizers), Azoty (a project called "Polimery Police" focusing on the development of installations for production of propylene and polypropylene) or Lotos (construction of hydrocracking unit) [Furman, 2021]. In the CEE countries the Hungarian conglomerate MOL Group is carrying out the investment Kompleks Polioli [Plastech, 2022]. Investments of oil companies result from the need to diversify non-fuel product range and expand petrochemical value chain towards a growing market of semi-products.

This report pays special attention to plastics manufactured from petrochemicals. Their significance is determined by factors such as growing demand and opportunities to deliver numerous benefits valued by the society, combined with potential reduction of the plastics' impact on the environment, in line with the principles of CE.

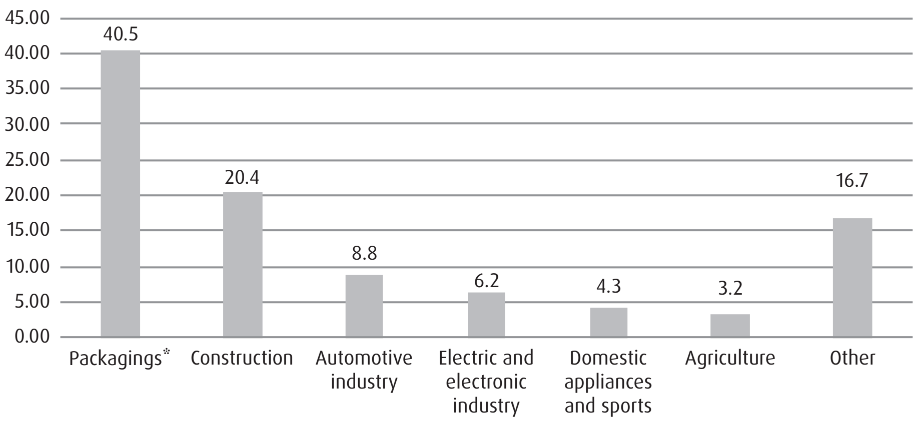
Plastics are present in virtually each sphere of life of contemporary Europeans. It is forecast that their use will be increasing in the coming years, as there are no substitutes that could replace them. For now, growing demand for plastics cannot be satisfied by plant-based products or recycled material obtained within CE. It should also be highlighted, however, that petrochemicals bring many risks for human health and even life, and for the environment, because they pollute soil, water and air. Therefore, it is vital to make efforts to eliminate plastic waste from the natural environment, as stipulated by sustainability framework of the strategy of the European Green Deal and the agenda for greenhouse gas emission reduction by 2020, covering, among other things, circularity.

Plastics are made by processing fossil fuels – mainly natural gas and crude oil. Growing demand for such goods requires stable sources of procurement of crude oil and natural gas – a big challenge, considering the current turbulence and disruptions in supply chains resulting from the pandemic and war in the regions where many EU countries have sourced these commodities. Hard coal can be potentially used to obtain substances indispensable in chemical production, due to the technology of coal gasification. However, because of declining role of coal, the extraction of which is to be phased out in the coming years, initial government's interest in this technology, deemed to be important for the state economic policy, will not help the Polish economy to become independent of natural gas imports. Data for 2020 show that over 38% of natural gas consumed in the EU was imported from Russia (in Poland the figure was approx. 55%, according to Eurostat), which is a problem in the face of uncertain supplies, risks and sanctions imposed due to the armed conflict in Ukraine on Russia and the company Nord Stream 2 AG, which has built the gas pipeline between Russia and Germany. Europe's dependence on Russian oil is smaller than its dependence on Russian gas.

Demand for plastics

The significance of petrochemical industry and plastics it manufactures is best described by the fact that all the sectors of the economy are somehow connected with it by, for example, demand for plastics and goods made from them. The major user of plastics in 27 EU countries (EU-27) and Norway, Switzerland and the United Kingdom is the packaging sector. It is followed by the construction, automotive, electric and electronic sectors, household appliances, sports products and agriculture (Figure 1). Other economy sectors with demand for plastics are the furniture, medical and mechanical engineering industries.

Figure 1. Sectors with demand for plastic products in 2020 (%)



* Trade and industrial packagings.

Source: Plastics Europe [2021, p. 20], data of Plastics Europe Market Research Group (PEMRG) and Conversio Market & Strategy GmbH.

Production in these industries, especially automotive, electronics and plastic sectors, was strongly affected by the COVID-19 pandemic, which pushed down not only demand for many products, but also their production volume, since economies were closing and facing hurdles in supplies of raw materials and components, caused by disruptions of global supply chains.

Problems on the supply side of industrial production could be observed in UE-27 already in 2021. Bottlenecks in the supply chains and deliveries of materials, as well as rising prices of commodities, semi-finished goods and energy (especially natural gas), combined with high transportation costs burdened production and impeded its fast growth, despite a strong foreign demand and rising number of industrial orders. According to IHS Markit's vulnerability index, four CEE countries, namely Hungary, Slovenia, Estonia and Czech Republic, struggled with large difficulties with supply, while Croatia, Romania, Bulgaria and Latvia were significantly less affected than other countries [IHS Markit, 2021]. Lithuania, Slovakia and Poland were in the middle in terms of vulnerability to these risks. Despite growing constraints on the supply side, output increased by 8.7% in relation to 2020 [Plastics Europe, 2022]. Automotive industry is the slowest to recover, as it is still experiencing problems with deliveries of semiconductors, microchips and other electronic devices, which resulted decreasing output volume in 2021 by over 19% than the year before [Plastics Europe, 2022]. Currently CEE countries, in particular Poland, struggle with increased shortage of labour, especially in logistics and construction, as many (male) Ukrainian workers are returning to their home country because of conscription to the army and involvement in the armed conflict.

Lower production volume in many sectors pushed down the demand for plastics in 2020, which was reflected by the functioning of European supply chains. Manufacturers of semi-finished products and plastic processing plants, plastic recyclers and machinery manufacturers recorded substantial drop both in output and demand. Still, this sector managed to keep high employment rate – almost 1.5 million people working in over 50 thousand businesses, mostly SMEs scattered across Europe [Plastics Europe, 2021]. In 2021, after three years of decline, European plastic manufacturers took advantage of high demand connected with global economic upturn, and output reached the level comparable to that of 2017. Nevertheless, many businesses had to deal with supply chain disruptions, bottlenecks and surging energy prices, which translated into prices higher than in 2020, when output drop was accompanied by price slump to the 2015 level [Plastics Europe, 2021].

Demand for plastics is concentrated in six biggest European countries, which represented almost 70% of market demand in 2020. These are Germany (23.3%), Italy (14.1%), France (9.3%), Poland (7.5%), Spain (7.4%), United Kingdom (7%) [Plastics Europe, 2021].

The European plastics system will be growing in the nearest future, and the demand for plastics is forecast to reach 48 million tonnes by 2050, which will account for 30 per cent growth compared to 2020 [SYSTEMIQ, 2022a]. These projections cover demand for plastics generated by four major recipient sectors in EU-27 and the United Kingdom, i.e. packaging, household appliances, construction and car industry. Demand for plastics in Europe has been growing in the last decade by 1–2% each year, and a substantial part of this growth was generated by permanent types of use, where plastics play an increasing role in alleviating the effects of climate change, e.g. by improving efficient energy use of buildings and economical use of vehicles [SYSTEMIQ, 2022a].

Trends in plastics supply chains

As mentioned before, it will be difficult to replace plastics by substitute products at the current stage of development. In order to address principles of sustainability and circularity, different directions and scenarios for the coming years are set, in line with the 3R rule (*reduce*, *reuse*, *recycle*).

The first principle covers measures aimed at reduced usage of plastics, particularly those that can be recycled. The development of consumer trends and green customer segments caring about environmentally friendly products are especially relevant. By their choices consumers may have an impact, on the one hand, on the reduction of plastics use e.g. by rejecting excessive packaging, and, on the other hand, on correct waste recycling, which allows for recovering materials for reuse. Thus, efforts should focus on streamlining the processes of collecting and sorting waste, and then their recycling to obtain high-quality recycled material that can be reused in manufacturing – something that businesses are obliged to do by EU regulations.

The second significant trend observed in certain industries is to replace plastics manufactured from petrochemical raw materials by products of plant origin. The sector of bioplastics, especially compostable ones, is investing in product and process innovations that will reduce the time of decomposition of such materials, not only in industrial composting facilities, but also in household compost bins. Opportunities to use compostable materials are sought mostly in the sector of food packaging and disposable products approved for food contact (e.g. cups, plates, cutlery). The prognoses are diversified, but progressive estimates of some experts reveal a potential to replace even 40% of traditional plastic packagings by biodegradable ones. These propositions should be addressed by the EU, whose regulations on implementing by 2023 obligatory collection of food waste should be complemented by a requirement to replace plastic shopping bags and bags for fruit and vegetables by bio-degradable ones. A pioneer in this field is Italy, which in 2010 adopted a law stipulating that food waste must be collected in reusable bins or food waste collection bags certified pursuant to EN 13432 standard on compostability. Since 2011 it has been banned in Italy to use disposable plastic shopping bags. Only compostable ones are permitted. Since 2019 the same regulations have been in force for disposable bags for fruit and vegetables. The bags may be used for collecting organic waste, since, due to being compostable, they can be put in food waste bins without polluting the compost. Furthermore, they simplify the process of composting food waste in industrial composting facilities and significantly reduce the cost of removing plastic bags from food waste. These measures are supposed to support circularity and stop the pollution of soil with plastic.

The third trend and possible development scenario for plastic producers and their client industries demonstrates the need to reconfigure global supply chains in terms of petrochemical products. The changes are necessary considering the risk of excessive dependence on the raw material supplies for petrochemical industry, especially natural gas, and also on the production of plastics in Asian and Middle East countries. This situation leads to higher risk of disruption caused by broken global supply chains. The need to diversify supplies of gas and oil will trigger a transposition of supply directions of these raw materials in the coming months. It is also worth to discuss an increase in investments in plastics manufacturing and thus in the petrochemical industry in the European countries having proper infrastructure and experience. Such strategic decisions, ensuring security of production and access to raw materials and semi-finished goods, will entail reconfiguration of supply chain structure and processes resulting from the change of supply directions. Higher costs of delivery and manufacture in Europe will be compensated by better production stability and lower vulnerability to the risk of disruption of deliveries from previous suppliers.

Uncertainty and risk of disruption as determinants of reconfiguration and building resilience of supply chains in CEE countries

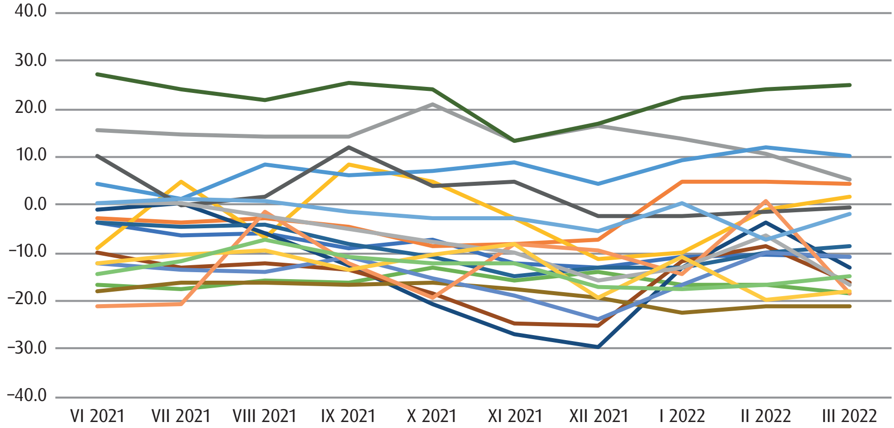
Supply chain disruptions

Assuming that the COVID-19 pandemic is in retreat, the short-term prospect of flow of goods in the European supply chains can be positive. A repeat growth of effectiveness, however, requires changes, as it is too early to be optimistic about the return to so-called normal, especially when local (Central European) value chains are still destabilised by a range of adverse, risky, and often unpredictable factors. Uncertainty and risk, including disruptions (which are the major issue in the context of negative changes affecting the efficiency of European supply chains of plastic and other petroleum products), are not the same thing, but are a common denominator for constraints originating both on the supply and demand side.

At this point let us establish the main sources and threats of disruptions of supply chains of plastic products. The first source of disruptions, most important from the perspective of the plastics market, is the supply area. Disruptions on the supply side (particularly with respect to production) affecting the supply chain stream among CEE countries, are caused mostly by [Seeking Alpha, 2021]:

- global delays in deliveries of raw materials, semi-finished goods and products for work-in-process, recorded in 2021 (Figure 2);
- shortage of labour;
- disrupted plan of infrastructural and suprastructural investments, which should be a natural instrument of supply chains recovery and resilience;
- insufficient pace of technology absorption, especially process automation as an alternative to manpower.

Figure 2. Deficiencies in supply of raw materials, goods and plastics in CEE in 2021–2022



	VI 2021	VII 2021	VIII 2021	IX 2021	X 2021	XI 2021	XII 2021	I 2022	II 2022	III 2022
Bulgaria	-3.9	-6.2	-5.8	-9.0	-7.4	-12.3	-13.2	-10.9	-10.6	-10.8
Czech Republic	-2.6	-3.9	-2.9	-4.7	-8.5	-8.3	-7.2	5.0	4.7	4.4
Estonia	15.4	14.6	14.0	14.4	21.0	13.5	16.4	13.6	10.7	5.4
Greece	-8.9	4.9	-6.8	8.4	4.9	-2.8	-11.4	-10.0	-1.1	1.8
Croatia	4.5	1.3	8.2	6.3	6.9	8.7	4.3	9.1	11.9	10.4
Cyprus	-16.8	-17.6	-15.8	-16.2	-12.9	-15.7	-13.8	-16.9	-16.9	-18.6
Latwia	-1.2	0.3	-5.9	-12.7	-20.6	-27.2	-29.7	-13.3	-3.8	-13.2
Lithuania	-10.0	-13.2	-12.2	-13.5	-18.5	-24.7	-25.1	-11.7	-8.7	-16.1
Hungary	10.4	-0.1	1.7	12.1	3.9	4.7	-2.2	-2.3	-1.4	-0.4
Poland	-18.1	-16.3	-16.1	-16.5	-16.4	-17.8	-19.4	-22.5	-21.0	-21.0
Romania	-3.5	-4.6	-4.2	-8.3	-10.8	-14.8	-13.1	-13.0	-9.9	-8.4
Slovenia	27.4	24.0	21.9	25.4	24.0	13.4	17.0	22.5	24.1	25.1
Slovakia	-12.0	-13.5	-14.0	-11.0	-15.5	-19.0	-24.0	-16.5	-10.0	-11.0
Montenegro	-21.1	-20.5	-1.3	-12.3	-19.3	-8.0	-9.5	-14.3	1.0	-18.5
Macedonia	0.3	0.4	-2.5	-5.0	-7.6	-9.8	-15.6	-13.2	-6.4	-16.7
Albania	-12.4	-10.2	-9.7	-13.6	-10.5	-8.0	-19.4	-10.8	-19.8	-18.1
Serbia	0.4	1.4	1.0	-1.6	-3.0	-2.8	-5.6	0.5	-7.5	-1.8
Turkej	-14.5	-11.8	-7.4	-10.8	-12.3	-12.2	-17.3	-17.5	-16.5	-14.7

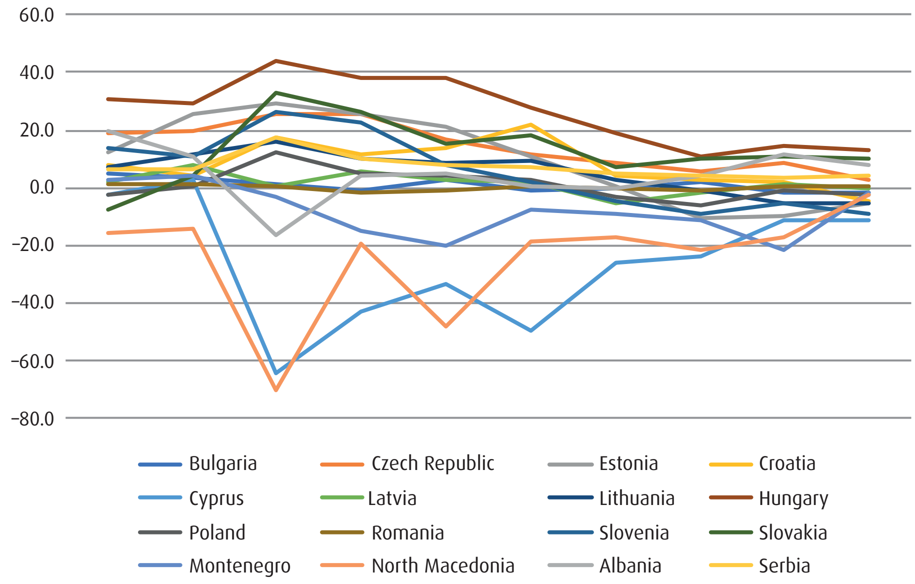
Source: self-reported data on the basis of Eurostat data [2022].

On the demand side, disturbance of the flow of goods along supply chains was caused by:

- short-term, yet dynamic changes, such as surge in demand for plastics (changes in demand negatively affect the rhythm of production);
- overloaded transportation system and rise in global production costs, including so-called price pressure;
- sudden increase in prices of consumer durables.

Paradoxically, despite these sources of disruptions, which have direct impact on the effectiveness of supply chains, particularly the flow of goods, from the perspective of demand a record number of orders for plastics and industrial orders in general can be observed, which is falling in the CEE countries, though (Figure 3).

Figure 3. New industrial orders in the CEE countries – flow of goods and plastics from Q4 2019 to Q1 2022



Source: self-reported data based on Eurostat data [2022].

Effects of lack of resilience of supply chains from the perspective of close and distant environment

Lack of resilience of industrial supply chains (including those in plastics industry) may be of endogenous origin, when decisions on flow management are disturbed [Marzantowicz, Nowicka, 2021], or may be caused by exogenous factors. In both cases the reference point is the surrounding environment. For close environment, attention should be paid to domestic cooperation within an international supply chain. Distant environment means directions of flow among cooperating countries within the same supply chain.

Lack of resilience of plastics supply chains in the close environment is determined mostly by functional risk [Marzantowicz, Nowicka, Jedliński, 2020], understood as disruptions and negative impact on the relations between specific chain links (businesses), and national law, human capital, finances, availability of technology, and local social pressure on the implementation of sustainability principles. As for distant environment, also operational risk should be taken into account [Marzantowicz, Nowicka, Jedliński, 2020], which refers to designing, planning, procurement, manufacturing, production and returns.

In the discussion about the distant environment, deliberations should address relations between the surrounding of the supply chains and their links. Here the direct sources of risks are enterprises, or logistics providers, distribution networks, supply and, naturally, demand. The risk connected with macro-environment is today one of the major risks in terms of measures making the supply chains more resilient to variable factors or (less commonly for global plastics supply chains) measures improving their flexibility. The reasons of such state lie in the economy, natural environment protection, society, technology, globalisation and other megatrends.

IHS Markit [2021] has developed and index of vulnerability to supply-side constraints, which allows to classify the eleven Central European countries in terms of their materials shortage and rate of price growth. Pursuant to the report prepared on the basis of this index, Hungary, Slovenia, Estonia and Czech Republic seem to be more vulnerable to supply constraints, while Croatia, Romania, Bulgaria and Latvia are in this respect more resilient than other countries of the region [IHS Markit, 2021]. It has not been specified, however (apart from lower short-term prospect of GDP growth for Europe), why flows of materials along the indicated directions differ among each other. It is nevertheless visible and presented on the chart showing industrial orders (Figure 3) that shortages of raw materials and plastics availability were unevenly distributed across sectors and European countries [IHS Markit, 2021].

Assuming, however, that the resilience of supplies of plastics and, broadly speaking, petrochemical products, in Europe is destabilised, and that stability is a challenge for effective flow of goods, it is worth to have a look at the effects of disruptions in both perspectives of close and distant environment. These are presented in Table 1.

The list of (mostly negative) effects is not comprehensive. A whole range of possible unpredictable factors should be considered that contribute to the insecurity in which petrochemical industry and plastics supply chains will be functioning.

Table 1. Effects of lack of resilience of supply chains on disruptions of flow of petrochemical products

Effects of lack of resilience in the close environment	Effects of lack of resilience in the distant environment
Exclusion of chain links or businesses from local and international market	Lower supply rate
Disrupted relations in national distribution networks	Disrupted sources of procurement
Shortage in customer demand	Disrupted sales network
Growing social pressure (customer needs)	Lack of control over potential relations with suppliers – low bargaining power
Increase in manufacturing costs	Lower demand rate
Increased disruptions and loss of resource stability	Drop in market value, low rating
Adverse external effects	Growing external costs

Source: self-reported data.

Need for reconfiguration – transposition of the force of flow of goods in plastics supply chains

Reconfiguration of supply chains, especially in respect of procurement forces, so that the supply in Europe keeps up with demand for plastics again, translates also into resilience of these supply chains. Resilience entails a need for change, supplementing or broadening directions of the force of goods flow both in the phase of procurement and distribution (taking into account circularity of these supply chains) with neighbouring countries in the east of Europe. However, it does not mean greater globalisation; quite the opposite – in the petrochemical industry this will mean raising production, procurement and distribution capacities in local scale.

Therefore, reconfiguration of petrochemical industry supply chains, including plastics, is justified by premises that seem obligatory from the point of view of European supply chains stability [compare Rotom, 2022].

1) First, an important issue is effective risk management, and to some extent uncertainty management. What is important here is the ability to build scenarios which, through prediction, go beyond the scope of safe risk. The point is to increase the rate of implementation of technologies, including digital technologies, which will allow to forecast, with greater precision, the pace of demand fluctuation (as it was mentioned above, the risk is also caused by factors on the demand side).
2) A key area of reconfiguration is also the scale of building resilience through flexibility [Capgemini, 2021]. The resilience refers to all the areas of supply chain, as it means complete readiness to introduce fast changes, in respect of instant increase or reduction of production, drop or growth of suprastructure capacity, including transport, as well as sources of procurement and outlets, taking into

account circularity principles – closing the circulation of goods in a supply chain (which reveals further premises). Flexibility is a key element of this process, since, according to research from 76 countries, as much as 56% of supply chains have been affected by various disruptions (cyberattack, accidents, scarcity of raw material) within just 12 months [Business Continuity Institute, 2018].

3) Transposition of forces, those referring to both supply and distribution, which limits the risk of disruption, to a closed flow cycle in the supply chain on the local CEE area seems to be vital, because from the point of view of major flows and reverse logistics shorter cycles are easier to close, which in turn enhances the response to changes and allows to achieve greater flexibility.
4) New, stronger CEE markets emerge due to resolute yet local diversification of suppliers, producers, distributors, and recycling or disposal facilities. This need for reconfiguration appeared as a result of global uncertainty both on Asian (mostly Chinese) and American markets. The point is to avoid depletion of resources on these markets, and to ensure possibility to close flow cycles in a flexible manner and to respond appropriately to disruptions (closer – easier). In this context, however, price competitiveness should also be taken into account. Surprisingly, the cost of flow of goods on the European and Central-Eastern markets is similar to European – Asian relations, and often even higher, which may reduce the readiness and willingness to effect the reconfiguration. In the situation of global uncertainty this factor is not the main determinant of the process, though.
5) Sustainable development as an inherent element of modern business has become an indispensable part of reconfiguration of plastics supply chains. The need for reconfiguration and resilience of supply chains is particularly evident for sustainability goals. Implementation of these principles in the European logistics is proceeding. It can be assumed that this refers more to the Western Europe than CEE, although it is still a question of the European countries' pace of growth, which covers also common, although non-obligatory regulations. They will be discussed in more detail further. The success of reconfiguration of plastics supply chains in the petrochemical industry depends directly on the principles and goals of sustainable development, including also tasks of CE.
6) Resilience of supply chains requires also effective secondary flow. In the case of a closed loop (understood as the requirement to reconfigure a supply chain towards circularity), closer distances between the chain links prove to be less vulnerable to disruption and are more flexible in respect of changing the flow direction. Although circularity goals are a challenge, they are attainable in the situation of stronger local flow forces, which is in line with the broader context of implementation of CE principles (more on this topic further in this article).

Reconfiguration of plastics supply chain, understood as a transposition of forces of goods flow to the CEE markets, is a condition of building resilience to events that might disrupt the processes, which translates into market instability also in the petrochemical industry. An important issue in building proper responsiveness of supply chains, however, is still instability of the major markets – United States and Asian markets (China). It is characterised by numerous unpredictable factors, which is a source of uncertainty, making it difficult to keep global supply chains resilient, all the more so since at the same time, despite global slowdown, the demand for plastics/petrochemical industry goods is growing. Circularity of supply chains of these products is one of the few responses and possibilities to stabilise the petrochemical market, especially when shifting the burden of procurement and distribution to CEE countries entails higher resilience of supply chains in Europe.

Determinants of plastics flow stability in supply chains as a part of delimitation of circular economy within the framework of implementation of sustainability goals

One of the key factors shaping supply chains of petrochemical products is the stability of supplies to the EU, which may pose a risk for these flows, in a situation where a significant part of imports will be concentrated among relatively few external partners. By April 2022 EU imports of crude oil, natural gas and coal depended mostly on Russia. In 2019 almost two-thirds of oil imports from outside EU came from Russia (27%), Iraq (9%), Nigeria and Saudi Arabia (8% each), Kazakhstan and Norway (7% each). In 2020 energy dependency rate [1] in EU-27 was 57.5%, which means that over a half of EU demand for energy was satisfied by imported raw materials. Poland, with its 42.8% energy dependency rate was below the EU average. The most dependent on imports of energy was Malta (97.6%), the least dependent was Estonia (10.5%). Poland was second in EU-27 (after Denmark) in respect of increase in energy dependency rate between 2000 and 2020 (increase by 32.1 pp., from 10.7% to 42.8%). At the same time average energy dependency rate in the EU remained on a similar level (56.3% in 2000, 57.5% in 2020). Poland's energy dependency rate in 2010–2015 fell from 31.6% to 29.8%, and then rose in 2015–2020 from 29.8% to 42.8% [European Commission [2022]. Let us note that CEE countries are experiencing destabilisation of supplies because of geopolitical events. Polish Chamber of Chemical Industry (PIPC)

1 Energy dependency rate is measured as a share of net imports (exports subtracted) in domestic gross energy consumption (total energy produced and net imports). It allows to establish the extent to which an economy relies in imported energy raw materials to satisfy its need for energy.

reports that in 2021 the value of imports of chemicals from Ukraine to Poland was EUR 297 million, and the value of exports from Poland to Ukraine was almost EUR 1.4 billion. Imports of chemical products from Russia to Poland in that time reached over EUR 1.6 billion, while exports of Polish chemicals to Russia exceeded EUR 1.8 billion. In the new situation that occurred with the pandemic and war in Ukraine, trade relations in many cases became short-term. "The warfare compelled Polish chemical firms to establish trade contacts with businesses from different countries than previously. This in turn pushes up prices of the products. The most necessary chemicals are less and less available, and their prices are much higher than before Russia's invasion on Ukraine (...). Bottlenecks in supply chains are already visible. It will take time for the situation return to normal, while production in chemical industry is continuous and feeds multiple economy sectors, which may collapse without these products or will be compelled to import certain components from distant parts of the world, such as Asia or both Americas – wherever it is possible, because the point is to ensure production and economic security [TVN24 Biznes, 2022][2]. The energy dependency rate will be changing, with simultaneous search for new suppliers of the same products and alternative raw materials ensuring the same effects as petrochemical goods. In effect, energy dependency may be an important factor stimulating development of alternative ways to satisfy needs, towards self-sufficiency or further diversification of supply sources.

The concept of sustainable development is based on economic growth attained through environmentally and socially friendly solutions, and one of the key tools enabling the application of sustainability goals are business models consistent with the idea of CE. Effects of CE are measured by circularity rate, which measures the share of materials recycled and reintroduced into the economy in the total materials consumption, thus reducing extraction of primary raw materials. Circularity rate covers flows of materials, fossil fuels and energy products, except water. During the last decade (2010-2020) average rate of circularity in EU rose by 2 p.p. In Poland the rate remained (with slight fluctuation) more or less the same, at around 10%. Among other CEE countries the lowest rate in 2020 was observed in Romania (1.3%), Bulgaria (2.6%), Latvia (4.2%) and Lithuania (4.4%). Countries with the highest rate of circularity in CEE were Estonia (17.3%), Czech Republic (14.3%) and Slovenia (12.3%). These were also the countries with the highest recorded growth of this rate. Precise data about individual CEE countries are presented in Table 2.

2 It should be noted that this situation also results in a shortage of workers in sectors such as transport, distribution and construction.

Table 2. Circularity rate in CEE countries in the years 2010–2020 (%)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EU	10.8	10.3	11.1	11.3	11.2	11.3	11.5	11.5	11.7	12.0	12.8
Bulgaria	2.1	1.8	1.9	2.5	2.7	3.1	4.4	3.5	2.5	2.3	2.6
Czech Republic	5.3	5.4	6.3	6.7	6.8	6.9	7.5	9.1	10.5	11.3	13.4
Estonia	8.8	14.2	19.1	14.6	10.9	11.3	11.6	12.4	13.5	15.6	17.3
Croatia	1.6	2.4	3.6	3.9	4.8	4.6	4.6	5.2	5.0	5.2	5.1
Latvia	1.2	2.9	1.3	3.8	5.3	5.3	6.5	5.4	4.7	4.3	4.2
Lithuania	3.9	3.6	3.8	3.1	3.7	4.1	4.6	4.5	4.3	3.9	4.4
Hungary	5.3	5.4	6.1	6.2	5.4	5.8	6.5	6.9	7.0	7.3	8.7
Poland	10.8	9.2	10.6	11.8	12.6	11.6	10.2	9.9	9.8	10.3	9.9
Romania	3.5	2.5	2.6	2.5	2.1	1.7	1.7	1.7	1.5	1.3	1.3
Slovenia	5.9	7.6	9.3	9.3	8.5	8.6	8.7	9.8	10.0	11.4	12.3
Slovakia	5.1	4.8	4.1	4.6	4.8	5.1	5.3	5.0	4.9	6.4	6.4

Source: Eurostat [2021].

The direction of development of EU economy sectors in the context of climate policy and sustainable development is expressed in the European Green Deal (EGD) [European Council, Council of the European Union, 2022]. These measures aim to reach climate neutrality in Europe by 2050, which requires, among other things, investment in environmentally friendly technologies, decarbonization of the energy sector, ensuring better energy efficiency of buildings or introducing cleaner means of private and public transport. Pursuant to the principles of Energy Union adopted in 2015, five major objectives of the EU energy policy are (1) to diversify Europe's sources of energy; (2) to ensure the functioning of a fully integrated internal energy market; (3) to improve energy efficiency and reduce dependence on energy imports, cut emissions, and drive jobs and growth; (4) to decarbonize the economy and move towards a low-carbon economy in line with the Paris Agreement; (5) and to promote research in low-carbon and clean energy technologies.

EGD initiated implementation of the strategy for climate-neutral, resource-efficient and competitive economy. Extended implementation of EGD principles onto business entities located in the entire EU is supposed to contribute to reaching climate neutrality by developing economic growth with limited resource consumption and ensuring long-term EU competitiveness. These goals are to be achieved by doubling circularity rate in the coming decade [European Commission, 2020]. It has been assessed that implementation of EGD principles in the entire EU may contribute to growth of EU GDP by additional 0.5% by 2030, and to creation of approximately

700 thousand new jobs [European Commission, 2018]. Reasons for the implementation of EGD are also obvious for individual EU production enterprises, which spend on average about 40% of their funds for materials and raw materials, while circularity solutions make it possible to raise profitability and at the same time to hedge against fluctuation of resource prices.

Under EGD, 55% of plastic package waste should be recycled by 2030. this would entail better design of such products in respect of their reuse possibilities, but it is also necessary to stimulate interest in the market of recycled plastics [European Council, Council of the European Union, 2021]. Processes transforming chemical waste into reusable raw material are greatly diversified, depending on the origin, characteristics and composition of the products. Recycling plants, waste incineration plants and hydrocracking units have a lifespan of at least 20 years. This means that investment decisions made in this decade, especially in the nearest three to five years, determine the way the European plastics system will look like in 2050. Technology suppliers need on average 17 years to reach the required growth, so capital investments made today will have long-term consequences and should be analysed and considered in such a long-term perspective.

Global production of plastics has risen in just a few decades – from 1.5 million tonnes in 1950 to million tonnes in 2018. The amount of plastic waste has grown accordingly. Although production volume dropped in the first half of 2020 because of the COVID-19 pandemic, it rebounded already in the second half of the last year. In Europe almost one third of plastic waste is recycled [European Parliament, 2021].

According to publications of the European Commission accompanying the implementation of Single Use Plastics Directive (SUP) on certain single use plastic products and packagings, 90% of such packagings become waste after single use. 80% of waste polluting the environment are takeaway food packagings and food and drink containers. At the same time, global recycling rate of plastic packaging waste is only 14%, and just 4% of plastic packaging and 1% of all the globally generated waste from single-use utensils, cups and food containers are recycled [Gospodarka Odpadami, 2022].

In response to these data in 2018 the EU adopted a package of waste directives, the aim of which is to transform the economic model from linear into circular one. It imposes more responsibility for post-consumer phase of the product life cycle on market participants – from manufacturers, to sellers, to consumers. Particularly strict regulations covered plastic drink containers, because of their high share in natural environment pollution and very low rate of recycling of takeaway food packagings. The SUP directive provides for high rate of recycling of plastic drink bottles and requires from manufacturers to use recyclates, recommending introduction of deposit-refund schemes for a broad range of materials, not only plastics [Gospodarka Odpadami, 2022].

In 2020 the EC released a chemicals strategy for sustainability [European Commission, 2020a], that aims to strengthen the existing legislative framework, while promoting innovation and the transition from hazardous to green chemicals. The main goal for Europe is to specialise in a portfolio of chemicals that are low-energy in their production, which do not create health or environmental risks, and that can themselves be safely reused and recycled. The strategy is part of the European Green Deal, and its aim is to achieve the zero-pollution ambition for a toxic-free environment.

The European Chemical Industry Council (CEFIC) has recommended that part of the strategy should be to develop a new EU 'Safe-and-Sustainable-by-Design' standard, and to support research in predicting the toxic effects of chemicals, in order to speed up innovation in developing new substances. The 2050 vision, according to CEFIC, would be that "the European economy has gone circular, recycling all sorts of molecules into new raw materials" [European Commission, 2020c].

The Commission roadmap on the chemicals strategy for sustainability, published in May 2020, notes that "production of safer chemicals, products and materials in Europe is not sufficiently incentivized, and frontrunners developing and using safer and more sustainable chemicals, modernising existing or developing alternative technologies and business models, are struggling to be competitive [European Commission, 2020c]."

According to the Commission's communication *A New Circular Economy Action Plan For a Cleaner and More Competitive Europe*, to increase uptake of recycled plastics and contribute to the more sustainable use of plastics, the Commission will propose mandatory requirements for recycled content and waste reduction measures for key products such as packaging, construction materials and vehicles [European Commission, 2020a]. In addition to measures to reduce plastic litter, the Commission will address the presence of microplastics in the environment [European Commission, 2020a].

Furthermore, the Commission will address emerging sustainability challenges by developing a policy framework on sourcing, labelling and use of bio-based plastics. It will be done based on assessing where the use of bio-based feedstock results in genuine environmental benefits, going beyond reduction in using fossil resources. In other words, this refers to use of biodegradable or compostable plastics, based on criteria for the applications where such use can be beneficial to the environment. It will aim to ensure that labelling a product as 'biodegradable' or 'compostable' does not mislead consumers to dispose of it in a way that causes plastic littering or pollution due to unsuitable environmental conditions or insufficient time for degradation [European Commission, 2020a].

Additionally, the Commission will ensure the timely implementation of the new Directive on Single Use Plastic Products to address the problem of marine plastic pollution while safeguarding the single market, in particular with regard to: harmonised interpretation of the products covered by the Directive; labelling of products and ensuring the introduction of tethered caps; and developing rules on measuring recycled content in products [European Commission, 2020a].

Protection against the impact on the European market of products with high carbon footprint will be also ensured by Carbon Border Adjustment Mechanism (CEBAM), providing level playing field for competition on the community market (for example in a situation where China and India will be buying cheaper Russian raw materials such as oil and gas, which can pose an even greater threat for the European chemical industry, if it is forced to buy them at higher prices from other suppliers [TVN24 Biznes, 2022].

According to the research *ReShaping Plastics*, both measures taken by industry representatives and regulations in force may double the system's circularity rate (from 14% to 33%) by 2030 (measured as a share of expected demand for plastics that will be reduced, reused or recycled). This would reduce CO_2 emissions by 11 million tonnes and eliminate 4.7 million tonnes of plastic waste sent to landfills or waste incineration plants by 2030, compared to the situation where the current system would be maintained (without additional measures) [SYSTEMIQ, 2022b]. Although this trend is positive, such initiatives may turn out to be insufficient, considering the volume of challenges. Activities of governments and businesses are not yet developed enough to deliver 10 million tonnes of plastics recycling by 2025 – a commitment made under Circular Plastics Alliance [European Commission, 2022] – and to adapt the sector to the trajectory of changes necessary to reach Paris and Glasgow climate agreement goals [United Nations, 2021]. To accomplish these commitments, considerable efforts will be required from the industry, regulatory bodies and other stakeholders, and still they are not being carried out fast enough for the assumed goals to be achieved.

Another important factor determining the success of processes aimed at reuse of waste is collaboration among entities. It often consists in collecting waste from an external entity by an owner of installation/technology that transforms it into either new final product or component used in further process. Some companies collaborating within their own business group and with external partners/recipients/clients in line with the idea of CE are ORLEN business group, PCC business group, BASF, DOW, CFI World S.A., NextChem, CLARITER [PIPC, 2022, p. 40].

After a slump of investments in innovation in the chemical sector (excluding pharmaceutical production) in 2010–2013, since 2014 a trend of growing investment spending in this field has been observed. However, the volume of spending for product and process innovation in the manufacturing of chemicals, rubber products and plastics in the Polish chemical industry is lower than for global leaders [PIPC, EY, 2017, p. 30]. Polish companies are barely entrepreneurial in respect of implementing process innovations. For example, a considerable part of funds of the first competition INNOCHEM, PLN 19 million (17% of total funding) was assigned to finance five applications from horizontal areas of process optimisation and low-emission manufacturing technologies. The lowest number of applications (one) referred to acquiring raw material that is strategically significant on the chemical market due to macroeconomic trends and global situation [PIPC, EY, 2017, p. 31].

The main market segments driving changes for enterprises in chemical industry are agriculture, construction, automotive and food industry. They are important for domestic enterprises due to the large share of revenues chemical businesses from these markets. The major problem hampering plastics recycling is the quality and price of a product from recycled material compared to its primary equivalent. Processors of plastics need large quantities of recycled plastics, manufactured in line with strictly controlled specifications and at a competitive price, which is still the main factor stimulating consumer choices. At the same time, consumer awareness of supply chains, and thus the source of raw materials' origin, is an important factor determining the flow of individual products, semi-finished products, materials, and, finally, raw materials, from diversified manufacturing sites. Conscious consumer choices in the context of their impact on the natural environment, are growing as a result of knowledge on the sources of goods' origin. Consumers are more and more interested in eliminating negative effects of man-made climate change, for example through informed choices, which determine the functioning of enterprises and their supply chains. Although price is still the basic criterion of the choice of a product, emerging alternative solutions stimulate more and more interest of a number of people.

Despite the significance of plastics as a pillar of the European industry and increasing attention paid to CE solutions, there are still big gaps in available data, which restrict the implementation of CE principles in economic practice. It is estimated that around 43% of plastics introduced on the European market are not included in waste statistics (around 22 million tonnes each year) [SYSTEMIQ, 2022b]. The data gap is also a challenge for understanding the impact of the sector on the environment and climate, and also for planning and implementing CE solutions, which also restricts research.

Further research, dialogue and collaboration between industry, government and civic society will be vital for ensuring stable investment climate and effective regulatory instruments shaping the development of European plastics market working in the conditions of net zero emissions circular economy. Reaching the expected level of system transformation will probably require establishing a body coordinating activities aimed at achieving CE, work on innovations and implementing industry projects on various layers of management, and also investments in infrastructure. Let us highlight some interesting and valuable initiatives occurring already, such as Circular Plastics Alliance or New Plastics Economy of the Ellen MacArthur Foundation, bringing together over 1000 organisations acting for transformation towards CE.

Summary

Petrochemical industry and technologically advanced petrochemical products may grow significantly in the coming years due to higher demand for plastics. Rising demand reported by packaging, automotive, construction, electronic and electric industries will be a trigger for investments in new projects implemented in the EU countries in response to the need for security and stability of plastics supplies. The industry is also facing other challenges connected with reduction of risks posed by plastics for human health and natural environment, as stipulated by sustainability framework of the *European Green Deal* strategy and the agenda for greenhouse gas emission reduction by 2020, covering, among other things, circularity. On the other hand, although potential substitutes of plastics are hardly available, some trends (such as reduced consumption of plastics, especially unrecycable ones, development of green customer segments caring about environmental issues or replacing plastics made from petrochemical raw materials by compostable plant-based products) bear certain threats for continued growth trend.

A challenge for reduction of risk and uncertainty in plastics supply chain management in Europe is also to maintain stable flows of goods and building resilience by changing the force of these flows, taking into account substantial diversification of both procurement and distribution on the CEE markets. Reconfiguration (this is how we should call the stabilisation of flows and resilience of supply chains) may be effected through activities covering basic criteria of contemporary, dynamic European market, referring in particular to guidelines for flexible demand forecasting, flexibility of supply chains, local diversification of raw material and product supplies, diversification of suppliers, obligatory implementation of sustainability goals and effective reverse logistics. However, now that the American and Asian markets are considerably unstable, an important thing is the ability to move around smoothly in the field of shaping supply chains in uncertain conditions. Proposed circularity of supply chains and their reconfiguration towards Eastern Europe is a response to the need to not only improve their resilience, but also to reduce and close the cycle of flow of plastics and other petrochemical products.

Determinants of the flow of products of the analysed sector in line with the CE model can be divided into supply-based and demand-based factors. The former include, among other things, readiness for transformation towards CE measured by circularity rate, EU regulations and recommendations, energy dependency rate, availability of alternative solutions, collaboration and partnership. Demand-based factors cover consumer choices conditioned by alternatives offered to them and growing awareness. The impact of the factors that affect the sector both stimulate and destabilise flow of goods, which makes their reconfiguration necessary. At the same time, they are often interrelated. The complex problem of stabilising the flow of goods is exacerbated by changeable exogenous factors and difficulties with diagnosing new potential events. Still, transformation of the sector towards CE is in progress, and because of the investment nature of relevant activities it will be possible to identify its effects only in the long-term.

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IMPACT OF ENERGY PRICES ON INFLATION PROCESSES IN THE ECONOMIES OF CENTRAL AND EASTERN EUROPE

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Abstract

The aim of the study is to analyse the impact of prices of the selected primary energy resources on inflationary processes in CEE countries. Empirical analysis confirms that there exists a close relationship between energy prices and inflation. In particular, a statistically significant causal relationship was confirmed between the price of energy resources, i.e. crude oil, natural gas and coal, and the level of inflation. CEE economies are still heavily dependent on fossil fuels, which is a consequence of their historical heritage and, to a limited extent, local presence of certain energy resources. A strong causal relationship was also diagnosed between the price of CO_2 emission allowances and the inflation level. Emission permits are an indispensable cost element that must be incurred when using fossil fuels. However, the causal relationship between electricity and inflation is different, as it can be observed with a one-year delay.

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The paper aims to analyse the impact of prices of selected primary energy carriers on inflationary processes in the countries of Central and Eastern Europe (CEE). The study starts from estimating the role of energy in contemporary economies, particularly focusing on the energy produced in CEE. Countries of the region have been defined in terms of the development and availability of their energy resources. These countries are strongly dependent on supplies from the East through oil and gas pipelines which some years ago had signified friendly relations with the Soviet Union. Further on in the paper, it was pointed out that the prices of basic energy resources such as crude oil, natural gas and coal have a significant bearing on how the CEE economies are faring. For three decades now we have seen some activities aimed at a gradual transformation of the energy systems in this region and their closer integration with the European structures. The market of electric energy serves a good example in this respect. The latter part of the paper describes the mechanism of fluctuations in the prices of electric energy as an important secondary energy carrier. Finally, in the empirical study section, a model was proposed to explain the causal relationships between energy prices and the inflation rate. The time scope accounted for is the years 2010–2020, the period characterised by a high dynamic of both primary and secondary energy carrier prices as well as by changes in the levels of inflation in CEE countries. The generally accepted delimitation indicates also the importance of the globally adopted framework for reducing the environmental impacts of the energy sector (the Paris agreement).

The role of energy in CEE economies

In the last decade the economic development of most countries of the world can be attributed mostly to energy. It was energy that determined the scope and pace of the structural economic change. Access to sources of primary energy defined the energy mix, technical conditions and cost of producing secondary energy: electric energy, heating/cooling or mechanical energy, which consequently determined the ability to implement quality and quantity changes in industrial production, services, urban development or settlement. For some countries, access to energy contributed to developing their resource strategies based on intensified mining and exports of energy resources, maximising profits and building an economic and political position based on the existing interdependencies.

Countries with no natural[1] resources have experienced multiple turbulences due to the increased dependence of the economic development on the access to energy. Firstly, the role of hydrocarbon exporters has strengthened. Decisions on the volume of exports and their geographic directions affect the level of prices and the behaviour of other market players. Secondly, countries have become more economically vulnerable to the consequences of price hikes in energy resources, which results both from the import dependence and the role of energy in the economy. Thirdly, free fluctuation in the energy mix has been constrained and more political dependence owed to the reliance on hydrocarbon imports has been observed.

Increased demand for energy sources and electric energy has been caused by the rising population[2], higher income levels and a changed structure of consumption of goods and services. Increased demand for hydrocarbons reveals a continuous presence of local and regional resource barriers. Despite the ongoing technological development, which may seem to be pushing this barrier, from time to time there appears a risk of an insufficient supply of particular energy carriers. At the same time, the environmental pressure is on the rise. Growing populations, higher demand for transport services and electric energy trigger monstrous emissions of CO_2 and bring vital concerns about the future of the natural environment. Climate change causes shifts in the use of primary energy carriers and shapes new climate and energy policies accounting not merely for the access to resources and their prices, but also for the short and long term consequences of the current decisions.

Simultaneously, the global transformation involving globalisation processes, international labour division and economic convergence has caused major shifts in the significance of countries as producers and consumers of energy. All the abovementioned processes gave rise to the concept of the energy climate era [Friedman, 2008], characterised by a dominant role of energy in creating conditions for economic development.

1 Natural resources are a special economic category, along with anthropogenic resources they constitute national wealth. As such, they do not merely set conditions and conducive circumstances, but become a determiner and a driving force of the economic and social development.

2 At the beginning of the 20th century, the world population amounted to 1.6 bn, in the 1970 s it was 4 bn, and in 2022 it reached almost 8 bn [Worldometer, 2022].

The significance of energy in contemporary economies is proved by the analysis of economic and social metrics which demonstrate that there exists a positive straight-line correlation between the access to energy and the volume of produced goods or services or the energy prices and inflation levels. A particular vulnerability of economies to changes in the volumes of the supplied/produced primary/secondary energy as well as their reaction to price volatility triggering inflationary processes call for some assessment, but also make it necessary to address the measures which could prevent these occurrences.

Energy prices and inflation

The most frequently applied metrics to measure inflation are the consumer price index (CPI or HICP)[3], and the deflator (calculator) of gross domestic product prices including price changes of all goods and services delivered in a given period, not only consumer goods, but also investment goods, raw materials and agriculture produce.

Inflation is caused by various intertwined factors, present both on the territories of individual countries and beyond them. Vulnerability to external circumstances depends on the degree of a given economy's openness or its reliance on imports. A frequently occurring type of inflation is the cost inflation caused by rising raw material prices, particularly the prices of energy resources, the role of which in economies has increased significantly. Increase in the prices of primary energy carriers, e.g. oil or natural gas induces a highly violent reaction of the economies. It is the consequence of the impact secondary energy prices have nowadays on the production of virtually any good or service and a vital role of transport costs. The level of sensitivity to price fluctuations is a function of the degree of dependence on a given hydrocarbon and a given energy resource's imports, the level of differentiation of the geographic trade directions as well as the structure of the energy mix. The countries which are most exposed to cost inflation are those which remain particularly reliant on the imports of energy resources and which do not possess sufficient resource deposits allowing to adequately meet the demand for electric energy as well as the countries where the quality structure of hydrocarbon use is only slightly diversified with a negligible share of other energy sources.

3 HICP (Harmonised Index of Consumer Prices) is estimated for the purposes of common EU statistics. Differences between HICP and CPI lie in the basket elements of each index. CPI is calculated according to a long time methodology of the Main Statistical Office (GUS) and is based on survey results of household budgets. HICP basket is created based on the uniform methodology adopted by Eurostat.

Characteristics of CEE countries in the context of conditions for development and accessibility of energy resources

CEE[4] is a term referring to a group of countries sharing a common geographical location, cultural and historical heritage, past dependence on the Soviet Union as well as having experienced the same economic transformation and development issues. Their communist past of over 50 years operating under a centrally planned command-and-control economy and then, after the collapse of this system, at the beginning of 1990 s, starting a systemic transformation into the new structures of market economies was marked by numerous hurdles deriving from a poor administrative framework, some entrenched communist economy habits, low environmental awareness, lack of quality standards and limited social consciousness.

The progression paths taken by CEE countries after 1989 have led to closing the wide development gap between them and the economically mature countries of Western Europe. High economic growth was possible due to low labour costs, attractive location in terms of capital investment and market growth, as well as fast expanding consumption. Most certainly, the quality and depth of their response depended not merely on the economic, monetary and fiscal policies adopted, the achieved levels of economic and social development, but also on the economic potential of these countries[5].

The early system transformation process was accompanied by a strong interest in expanding cooperation with the countries of EEC. It was expressed in signing numerous agreements on economic or commercial cooperation, associating with the European Union and then in EU membership treaties.

The period of association with the EU and then applying for EU membership supported and accelerated the process of system transformation taking place in CEE countries[6] which constitute a numerous and disparate group in terms of their economic potential, spatial conditions, as well as environmental, infrastructural, social and cultural features (Table 1).

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4 Economists of the mainstream usually indicate fluctuations in supply, demand, employment and wages. According to monetarists, the source of inflation lies with excessive money supply in relation to the supply of goods on the market.

5 Geographers have been identifying the region of CEE as comprising 21 countries. For the purposes of this study the group was narrowed down to: Lithuania, Latvia, Poland, Slovakia, the Czech Republic, Hungary, Croatia, Bulgaria, Slovenia, Estonia and Romania.

6 Transformation processes in the countries of the region followed various development strategies [cf. Offe, 1999; Bożyk, 1999; Mayer, Scharrer, 1997].

Table 1. Volume and structure of GDP and energy supply with main energy carriers in 2020

Country	Area (km^2)	Population (thousand people)	GDP *per capita*	GDP structure (%)			Resource deposits	
				agriculture	industry	services	crude oil (m bbl)	Natural gas (bn m^3)
Bulgaria	110 910	6591	10 079	4.3	28.0	67.4	15	5.6
Croatia	56 542	4058	14 134	3.7	26.2	70.1	71	24.9
Czech Republic	78 866	10 693	22 931	2.3	36.9	60.8	15	3.9
Estonia	45 226	1329	23 027	2.8	29.2	68.1	0	0.0
Lithuania	65 200	2794	20 233	3.5	29.4	67.2	12	0.0
Latvia	64 589	1907	17 786	3.9	22.4	73.7	0	0.0
Poland	312 679	37 958	15 720	2.4	40.2	57.4	126	79.8
Romania	238 391	19 329	12 896	4.2	33.2	62.6	600	105.5
Slovenia	20 273	2095	25 517	1.8	32.2	65.9	0	0.0
Slovakia	49 035	5457	19 266	3.8	35.0	61.2	10	14.1
Hungary	93 030	9769	15 980	3.9	31.3	64.8	24	6.6

Source: self-reported data based on IEA [2022] and, Eurostat [2022] and World Bank [2022].

All across the region, economic development and sustainable GDP growth continue to be noted. Apart from Romania, all countries are economically highly developed, with GNP *per capita* exceeding 12 696 USD. Their economies have similar structures: a dominant tertiary sector, a small share of the primary sector and a 30% share of the secondary industrial sector. Industrial output and the quality of services provided, as well as changes in the spatial organisation (urban development, growing technical infrastructure) boost demand for energy resources and electric energy.

CEE countries have relatively scarce deposits of hydrocarbons. Only the deposits of black coal, natural gas and crude oil in Poland and Romania may be considered significant as compared to other countries of the region, yet even these are insufficient to provide resource independence. National oil extraction in Romania (in the regions of Ploeszti and Pitești) covers only half of the demand for this resource. Romania extracts also natural gas which covers 70% of the Romanian economy's demand for coal – 35.4 m tonnes annually. As a comparison, in Poland natural gas extraction covers about 20% of the demand, oil extraction in 2020 accounted for 733 thousand tonnes.

In Hungary, there are scarce black coal deposits and the national production of natural gas and crude oil covers 19% and 20% of the demand for these resources respectively. There are some rare deposits of black coal, crude oil and natural gas in Bulgaria and Croatia, Slovakia has some coal and gas, but Lithuania, Latvia and Estonia have no access to own deposits of energy resources.

Trends in energy supply and demand

Membership in the EU became a significant growth factor for CEE countries. Making community legislation part of the national law resulted in structural economic changes and gave rise to building new development strategies in all economic fields including energy management.

Table 2. Energy consumption in CEE countries in 2020

Country	Energy supply (TJ)				Primary energy consumption (thousand tonnes)			Final energy consumption (thousand tonnes)		
	black coal	crude oil	natural gas	other	2000	2010	2020	2000	2010	2020
Bulgaria	213 452	187 990	102 234	220 000	17.7	7.4	17.2	9.1	8.8	9.5
Croatia	17 640	128 925	100 733	90 000	7.8	8.9	7.8	6.0	7.2	6.5
Czech Republic	509 903	355 028	304 646	350 000	39.2	42.5	37.5	25.1	25.3	24.5
Estonia	108 231	0	14 576	81 000	4.6	5.6	4.3	2.4	2.9	2.8
Lithuania	6394	115 612	82 553	69 000	6.5	6.2	6.2	3.8	4.8	5.3
Latvia	984	56 327	38 111	79 000	3.8	4.6	4.3	3.3	4.1	3.9
Poland	1 667 192	1 213 366	715 468	450 000	84.9	96.6	96.5	55.1	66.3	71.0
Romania	205 463	404 032	382 802	390 000	34.9	33.0	30.9	22.7	22.5	23.5
Slovenia	43 994	79 126	30 795	120 000	6.3	7.0	6.1	4.6	5.1	4.4
Slovakia	90 768	140 061	170 552	260 000	16.4	16.7	5.2	11.0	11.5	10.3
Hungary	68 627	304 756	366 421	300 000	23.6	24.6	23.9	16.2	17.5	18.0
EU27	–	–	–	–	1396.5	1457.3	1236.5	979.5	1024.0	906.8

Source: self-reported data based on Eurostat and IEA [2022] and CIA [2022].

In the past two decades diverse approaches to the primary and final energy consumption could be seen in various regions of Europe. Slumps observed in the EU in the studied period were accompanied by increased demand for primary energy in Poland, Latvia and Hungary as well as a significant rise in the consumption of final energy in most CEE countries. Only the Czech Republic, Slovenia and Slovakia showed a downward trend (Table 2).

These trends can be attributed to the dynamic development of all the countries in the region in the studied period. A rising demand for primary energy carriers and their insufficient domestic supply stimulated more imports (Table 3).

Table 3. Energy import dependence in EU member states from CEE in the selected years (%)

Countries	2000	2010	2020	Change 2020–2022 (p.p.)	Imports in 2020	
					crude oil (bbl/day)	natural gas (bn m^3)
Bulgaria	46.4	40.1	37.9	−8.9	133.900	3.2
Croatia	48.5	46.7	53.6	+5.1	55.400	1.8
Czech Republic	22.7	25.4	39.9	+17.2	155.900	8.9
Estonia	33.9	14.7	10.5	−23.4	0.000	0.5
Lithuania	57.8	79.0	74.9	+17.1	182.900	2.5
Latvia	61.0	45.5	45.5	−15.5	0.000	1.2
Poland	10.7	31.6	42.8	+32.1	493.100	15.1
Romania	21.9	21.4	28.2	+6.3	145.300	1.2
Slovakia	65.1	64.4	56.3	−8.8	0.000	0.9
Slovenia	51.9	49.3	45.8	−6.1	111.200	4.9
Hungary	54.9	56.9	56.6	+1.4	121.000	13.4
EU-27	56.2	55.8	57.5	+1.3	–	–

Source: self-reported data based on Eurostat, IEA [2022] and CIA [2022].

In the last two decades the dependence of EU-27 on energy[7] imports amounted to 56.2% in 2000, 55.2% in 2010 and 57.5% in 2020. The average value of this indicator for CEE countries stood at 48.3%, 43.2% and 49.9% respectively. In the years 2000–2020 the dependence on energy imports in the CEE region grew by 1.6 p.p. as compared to the increase of 1.3 p.p. observable in EU-27.

Moreover, a considerable diversity in the direction of change in this indicator, not so much its dynamics can be noted in CEE countries. Estonia, Latvia, Bulgaria, Slovakia and Slovenia managed to significantly reduce their reliance on energy resource imports as opposed to Poland, the Czech Republic, Lithuania, Romania and Croatia. Estonia remains a definite leader in EU-27, having made great progress by increasing its domestic production of renewable energy and reducing consumption, as a consequence it cut down on the demand for fossil fuel imports.

[7] These processes had mutual effect, and studies of the Polish economy indicate that systemic changes gained momentum thanks to advancing adaptation activities which resulted from the association agreement between Poland and the EU [cf. Wojtkowska-Łodej, 1997]. Accession of CEE countries to the EU continued to diversify the structure and volume of the energy resources held within the EU, which translated into increased demand for primary energy carriers and electric energy, stronger dependence of the EU on the imports of particular energy carriers, a necessity to make new investments in infrastructural connections with subsequent member states and growing impacts on the natural environment owed to exhaust emissions. The situation emerging after the eastern EU enlargement constituted a major challenge to the new European cooperation between member states of the EU-27.

In 2020 in CEE countries, 96.5% of total consumption of crude oil and petroleum products was supplied from imports. For natural gas this share was 83.6%, and for solid fuels – 35.8% (Table 4). In most countries of the region the level of dependence on oil and gas imports was significantly higher than the average value of the indicator in EU-27. At the same time, during the past two decades in Croatia, Poland, Slovakia and Hungary the imports of coal increased, whereas in Bulgaria, the Czech Republic, Lithuania, Romania and Slovenia they were reduced.

Table 4. Structure of hydrocarbon fuel imports dependence by type in CEE countries in selected years (%)

Countries	2000			2010			2020		
	solid fuels	natural gas	crude oil***	solid fuels	natural gas	crude oil***	solid fuels	natural gas	crude oil***
Bulgaria	35.2	93.5	96.0	24.5	92.6	101.9	9.2	96.4	97.5
Croatia	110.9	40.9	61.0	102.5	18.1	80.6	391.8	68.8	73.7
Czech Republic	21.9	99.8	95.3	−15.3	84.8	96.5	12.9	86.0	101.2*
Estonia	125.2	100.0	101.5	132.7	100.0	95.8	105.9	100.0	130.2
Lithuania	101.7	100.9	100.9	95.7	99.7	98.7	87.9	98.9	102.7
Latvia	84.1	101.9	94.9	106.5	61.8	94.4	89.0	100.1	105.6
Poland	−28.9	66.3	99.7	−4.9	69.3	98.2	0.4**	78.3	96.9
Romania	25.5	19.8	34.4	16.9	16.8	52.6	22.0	16.6	64.7
Slovakia	80.2	98.8	92.5	75.7	99.9	98.4	83.3	88.1	101.9

The result over 100 means that a given country imports the resource and is its exporter at the same time (it also applies to processed products). ** The first positive result in coal imports dependence was recorded in 2018 and it accounted for 8.2%, one year later it stood at 6.0%. *** Applies to petroleum products.

Source: self-reported data based on Eurostat data.

The abovementioned processes of increased dependence on the imports of primary energy carriers in CEE countries are accompanied by a considerable concentration of their supplies from Russia (Table 4). The situation of particular countries of the region in terms of supplies of primary energy fossil carriers is varied. For some of them Russia is a sole or dominant supplier of all the mentioned energy resources, others like Hungary, Poland, Estonia, Lithuania, Latvia, Croatia, the Czech Republic and Slovenia import mainly gas from Russia.

Such a strong reliance on cooperation with the country fighting a war affects heavily the security of deliveries, and in the face of the embargo on energy resource supplies, it may lead to increased prices of energy carriers on the world markets. What is more, it puts the countries of this region in a difficult position as they must compete against other EU member states for new supply channels of oil, gas and coal to cover their local domestic demand. In order to prevent this, suitable transactions should be implemented for the purchase of these resources by particular EU member states including countries of CEE.

Electric energy is a product of great significance to the functioning of modern societies. CEE countries are strongly dependent on fossil fuels (mainly coal and natural gas) as resources used for electric energy production, their relatively obsolete and inefficient energy installations carry the highest marginal cost. For example, in power plants whose emissivity exceeds 1000 kg of CO_2 equivalent/MWh, the cost of CO_2 emission allowances accounts even for 60% of the retail electric energy price. It applies chiefly to coal assets based on brown coal, as well as power plants of very low efficiency which are operated mostly during the periods of increased demand for electric energy. Comparing average emissivity of coal power plants in Poland and those of Germany or EU, it must be stated clearly that Polish power plants' emissivity is significantly higher and accounts for about 710 kg of CO_2 equivalent/MWh[8].

Table 5. Selected indicators affecting the volume of greenhouse gas emissions in CEE[9] countries in selected years

CEE countries	RES share in final energy consumption (%)			Greenhouse gas emission intensity during energy use*	
	2004	2010	2020	2010	2019
Bulgaria	9.2	13.9	23.3	117.4	97.1
Croatia	23.4	25.1	30.0	96.5	86.6
Czech Republic	6.3	10.5	17.3	83.6	76.3
Estonia	18.4	24.6	30.1	99.6	79.8
Lithuania	17.2	19.6	26.8	124.5	102.6
Latvia	32.8	30.4	42.1	96.0	83.8
Poland	6.8	9.3	16.1	93.3	84.2
Romania	16.8	22.8	24.5	86.3	85.4
Slovenia	18.4	21.1	25.0	99.9	89.8
Slovakia	6.4	9.1	17.3	89.1	77.7
Hungary	4.4	12.7	13.9	83.9	77.3
EU-27	9.6	14.4	22.1	100.0 91.9	82.6

* Columns show indices with bases referring to the year 2000.

Source: self-reported data based on Eurostat data.

8 The level of energy import dependence allows to estimate the share of energy imports from other countries in the total energy consumption of a given economy. This indicator is calculated as a quotient of net imports (minus exports) and the available gross energy.

9 The price of electric energy is set in relation to the power plants with the highest marginal costs, therefore the data used for various studies represent emissivity figures of the least efficient installations

The coal structure of electric energy production in dynamically developing CEE countries results in high greenhouse gas emissions. Intensity indicators of this problem (converted into CO_2) combined with the energy consumption in 2019 as compared against 2000, in almost all countries of the region (apart from Lithuania in 2019), have shrunk, although the scale of the change differed (Table 5). The lowest value of this indicator and simultaneously declining greenhouse gas emissions in 2019 could be seen in the Czech Republic and Hungary [Wojtkowska-Łodej, Nyga-Łukaszewska, 2019].

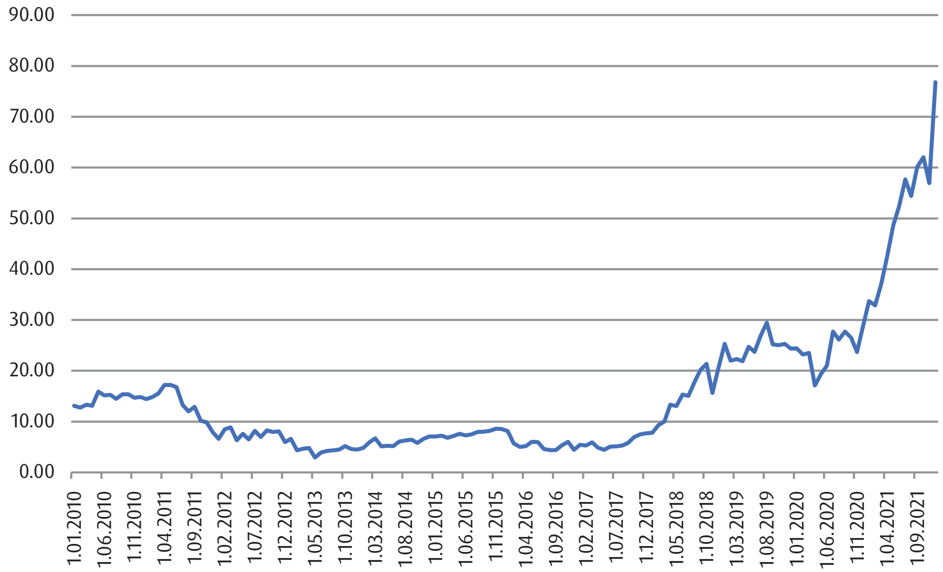
In CEE countries we can observe a significant rise in the share of RES in the final energy consumption, particularly in the Czech Republic (+11 p.p.), Estonia (+10.9 p.p.), Slovakia and Hungary (+9.5 p.p. each). It should be pointed out that some of those countries have made a considerable progress in the use of RES. The share of RES in the consumption of final energy in the years 2004–2020 was the highest in Bulgaria with a recorded rise of 20 p.p. Bulgaria was followed by Slovakia (+10.9 p.p.), Latvia (+10 p.p.), Lithuania (+9.6 p.p.), Poland (+9.3 p.p.), Romania (+7.7 p.p.) as well as Croatia and Slovenia (+6.6 p.p. each). However, the size of emissions and a rising level of final energy consumption produced a higher emission intensity ratio in this region.

Energy price fluctuations in CEE countries

The ways in which electric energy markets operate in the EU is affected by economic, political as well as environmental and climate factors. The EU energy and climate policies are geared towards attaining the so called climate neutrality by 2050 [Wojtkowska-Łodej, 2021, pp. 1–10]. The key market tool allowing for a reduction in the scale of net greenhouse gas emissions is the EU system of trading CO_2 emissions – the European Union Emissions Trading System (EU ETS). The mechanism affects directly the economic account of companies (internalised negative externalities) through a gradual reduction in the number of obligatory CO_2 emission permits in the energetic system, which pushes their prices up.

Until recently, the use of the EU ETS mechanism has kept the prices low, below 20 EUR/t until the end of 2017 (Figure 1), at the same time maintaining their high supply. In the following years, however, these prices kept growing, which was encouraged by keen actions aimed at stricter reduction of greenhouse gas emissions under the EU climate and energy policies. As Stage 4 of the EU ETS implementation began in 2021, with its increased pace of reduction in the available permits from 1.74% to 2.2% annually, recently we have seen a high price dynamic of these permits which reached their historical high (76.8 EUR/t) at the end of 2021[10]. This volatility of CO_2 emission permit prices was originally determined by the transformation of the energy sector in the EU countries, including CEE. Over time, unexpected circumstances started to play up which wound up the excessive price dynamic ("black swans", mostly in the form of the COVID-19 pandemic or the military conflict in Ukraine).

Figure 1. Prices of CO_2 emission permits in the years 2010–2021 (EUR)



Source: self-reported data based on Reuters data.

Rising prices of CO_2 emission permits are paramount for CEE countries and electric energy production. These changes have significantly driven up electric energy prices mostly in coal-based economies, i.e. Poland and the Czech Republic, where electric energy obtained from the combustion of solid fuels accounts for 68.9% and 39% of their energy mix respectively.

The EU ETS mechanism in principle encourages member states to commit to their energy transformation and use low-emission technologies, yet it also exerts a heavy impact on electric energy prices and as such is pro-inflationary, which has been proven by the findings of the conducted empirical study. The study aimed at verifying the

10 Greenhouse gas emission intensity ratio is calculated as a relation of greenhouse gas emissions to the gross national energy consumption. It stipulates how many tonnes of CO_2 equivalent are emitted in a given economy per one unit of the energy consumed. The energy emission data come from greenhouse gas emission reports filed with UNFCCC.

existence of a cause-and-effect relationship between the three types of relations: electric energy prices in relation to energy resource prices, inflation in relation to energy resource prices and inflation in relation to the emission permit prices. Due to the cyclical availability of the data, the analysis of the first relation was based on half-yearly data from the period between the 1st half of 2010 until the 1st half of 2021, in the remaining cases monthly data were used from the period of January 2010 to December 2021 – in each instance relating to the 11 CEE countries. The study employed Eurostat data (electric energy prices, inflation) and Reuters data (energy resource prices, CO_2 emission permit prices). HICP (Harmonised Index of Consumer Prices) represents the inflation rate reflecting changes in the prices of consumer goods and services purchased by households (a 12-monthly average price change rate was used in the study). The other variables show the levels of corresponding prices, i.e. the prices of crude oil (USD/bbl), natural gas (USD/m^3), coal (USD/t), CO_2 emission permits (EUR/t), as well as electric energy (EUR/kWh). The study used benchmark prices of energy resources which, at any given moment, were identical for all countries studied. Therefore, a CIPS panel data stationary test created by Ima, Pesarana and Shina [2003] was used for inflation and electric energy prices, and an ADF test was applied for emission permit prices and energy resource prices (in both cases latency periods were assigned based on the Schwarz Criterion).

Stationary test findings presented in Table 6 indicate that HICP series are stationary and that the other series represent a first order integration, therefore in the causality study the inflation rate levels and single-period relative change data were used directly in relation to other factors.

In order to conclude that there exists an influence (not merely a covariation), a relevant causality test must be performed in the study. Thus, the study applied a causality test created by Granger. In the analyses of each of the above mentioned relations, ARDL models with a maximum of 4 lags – in the study using half-yearly data – and 12 lags – with the monthly data were used, the final number of lags was assigned based on the Schwarz Criterion, and for some cases in the last column of Table 7, a possible divergence in conclusions was indicated, should they derive from a larger adopted number of lags (it may indicate a delay in the existing relation of influence). In Table 7, Granger test *p*-values were provided (Granger *p*-value column), which requires to assume that the test equation parameters are stable in relation to all CEE countries. Alternatively, adopting the analogical Dumitrescu-Hurlin test allows for parameters to be varied. It should be noted, though, that using this test causes a larger loss of degrees of freedom (DH *p*-value column).

Table 6. Stationary test results

Variable	Test 1 statistics (0)	5% critical value	p-value	Test	Test 1 statistics (1)	5% critical value	p-value	Test	Conclusion
HICP	−3.79	−2.25	–	CIPS. lags(2)	–	–	–	–	I(0)
Electric energy price	−2.142	−2.25	–	CIPS. lag(1)	−5.25	−2.25	–	CIPS. lag(1)	I(1)
CO_2 emission permits	4.71	–	1.00	ADF. lag(1)	−4.26	–	0.00	ADF. lag(2)	I(1)
Crude oil prices	−1.62	–	0.47	DF	−10.67	–	0.00	DF	I(1)
Coal prices	−1.93	–	0.32	ADF. lag(1)	−8.61	–	0.00	DF	I(1)
Natural gas prices	−2.51	–	0.11	ADF. lag(3)	−15.44	–	0.00	DF	I(1)

Source: self-reported data

Table 7. Results of the empirical study into causal relations

Dependent variable	Independent variable	Maximum order of lag	Lags	Granger p-value	DH p-value	Data	Notes
Electric energy price	crude oil prices	4	1	0.51	0.17	$n = 11$ $T = 21$	Granger p-value < 0.01 for lags ≥ 2
	coal prices	4	1	0.33	0.26	$n = 11$ $T = 21$	Granger p-value < 0.01 for lags ≥ 2
	natural gas prices	4	1	0.53	0.84	$n = 11$ $T = 21$	Granger p-value < 0.01 for lags ≥ 2
	fossil fuel prices*	4	1	0.00		$n = 11$ $T = 21$	
HICP	crude oil prices	12	3	0.00	0.84	$n = 11$ $T = 140$	DH p-value < 0.01 for lags ≥ 8
HICP	coal prices	12	3	0.00	0.00	$n = 11$ $T = 140$	
HICP	natural gas prices	12	3	0.17	0.41	$n = 11$ $T = 140$	Granger oraz DH p-value < 0.01 for lags ≥ 4
HICP	fossil fuel prices*	12	3	0.00		$n = 11$ $T = 140$	
HICP	CO_2 emission permits	12	3	0.00	0.00	$n = 11$ $T = 140$	

* The model accounting for the prices of oil, natural gas and coal in one equation following the approach proposed by Joudis at al. [2021].

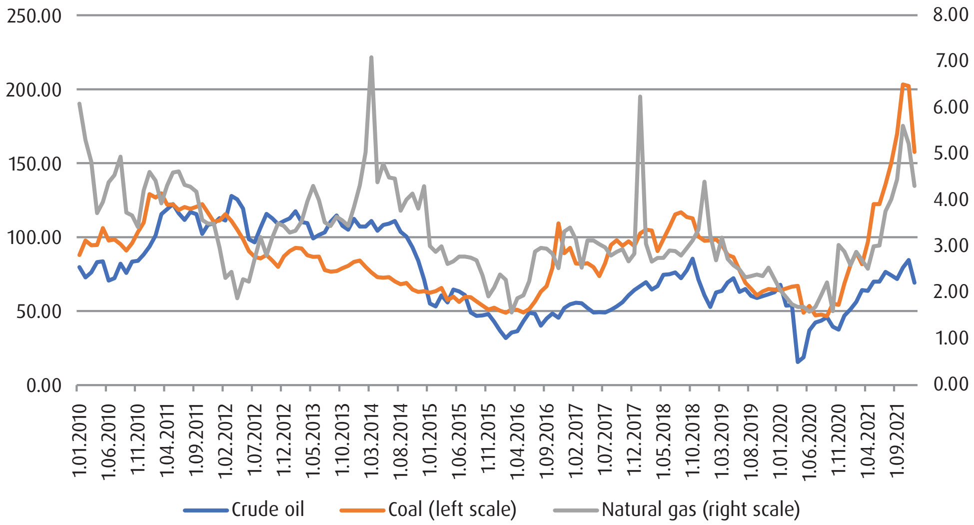
Source: self-reported data.

Both the Granger test as well as the DH test did not prove the existence of influence of the studied independent variable on the dependent variable in any of the CEE countries. It proves the validity of the zero hypothesis as opposed to H1 hypothesis, according to which this influence may be found at least in some countries of the region.

In the light of the above, it may be stated that in the group of CEE countries there exists a statistically significant influence of the CO_2 emission permit prices on the inflation rate.

In the case of electric energy production, apart from the CO_2 emission permit prices, the prices of basic energy resources, i.e. coal and gas, also play a vital role. Price dynamics of these resources became exceptionally high towards the end of Q1 of 2020, when prices of natural gas and coal saw 3–4-fold increases in the next quarters of 2020 and 2021 (Figure 2).

Figure 2. Prices of basic fossil fuels – crude oil (bbl), coal (tonnes) and natural gas (m^3) – in the years 2010–2021 (USD)



Source: self-reported data based on Reuters data.

Originally, the reason for such significant price rises was the economic expansion in many world economies (including CEE countries) following the COVID-19 pandemic, so keener demand meeting limited supply led to global spikes in energy resource prices. The pandemic left its mark also on the production of electric energy, as the share of coal in the energy mix fell considerably (up to 15% in the entire EU), while the demand for gas remained unchanged (21%). The recorded decline in the production of electric energy obtained from the combustion of coal amounted to 6 TWh between Q4 2019 and Q4 2020, while for gas a rise of 3 TWh was noted in the same time period. On the other hand, the production of energy from RES grew by 8 TWh. The share of brown coal in CEE countries between Q4 2019 and Q4 2020 shrank by 4%, and by 6% in the Czech Republic. The greatest slump in the production of electric energy from brown coal took place in Bulgaria (of 30%) and Romania (of 20%), where it was most frequently replaced with gas, biomass or energy produced in hydropower plants (e.g. in Romania) [Wojtkowska-Łodej, Nyga-Łukaszewska, 2019, pp. 91–110].

Currently, the most significant factor affecting global fossil fuel prices is the military conflict in Ukraine and the sanctions as well as embargoes announced by numerous countries (including the EU), the implementation of which may greatly curtail regional supply of energy resources in CEE. The very announcement of possible sanctions on hydrocarbons drove their price dynamics, which proved particularly harmful to the economies of the CEE region that are strongly dependent on hydrocarbon imports from Russia. Interestingly, higher gas prices in Europe paradoxically increased the profitability of producing electric energy from coal, although this fuel became relatively expensive itself, and the increased use of coal for electric energy production drove CO_2 emission permit prices [Księżopolski, Maśloch, Kotlewski, 2021, p. 302][11].

In the face of growing prices of energy resources, it is generally assumed they also are inflationary in nature. To verify this hypothesis, an empirical study was conducted which found out that in the years 2010–2021 there existed a causal relationship between the prices of energy resources and inflation.

Considerable fluctuations were seen both in the prices of CO_2 emission permits and energy resources in the studied period of 2010–2021 (first half-year), at the same time some volatility was noted in the prices of electric energy. In almost all countries of CEE the increase in prices of this type of energy was between 12% (in Croatia) and 49% (in Romania). Hungary was a sole exception, as the prices of electric energy supplied to households fell there by 41% (a decline from 0.17 EUR to 0.10 EUR; Table 8).

As mentioned before, the demand for electric energy in CEE has been satisfied using traditional primary energy carriers, mostly coal and natural gas. Therefore, in a vital majority of countries in the region it is fossil fuel prices which determine the price of electric energy. The conducted study showed an immediate causal relationship between the price of energy carriers and the inflation rate, but in the case of prices of electric energy supplied to individual users this correlation took place with a one-year delay, which results from the deal-making process for coal or gas deliveries, as well as from natural delays in administrative rate changes.

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[11] Thus, we could see further price spikes in the following months, with a historical ceiling at the level of 100 EUR/t.

Table 8. Prices of electric energy in CEE in selected years (EUR/kWh)

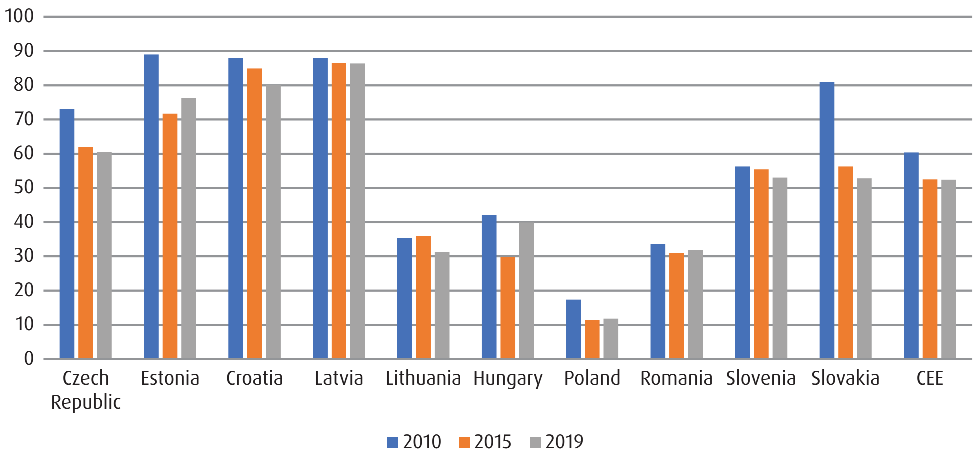
Country	2010 (1st half)	2015 (1st half)	2019 (1st half)	2020 (1st half)	2021 (1st half)	Change 2010–2021 (%)
Bulgaria	0.0813	0.0942	0.0997	0.0997	0.1024	26
Czech Republic	0.1496	0.1385	0.1748	0.1841	0.1802	20
Estonia	0.0970	0.1302	0.1357	0.1236	0.1324	36
Croatia	0.1151	0.1317	0.1321	0.1301	0.1291	12
Latvia	0.1049	0.1635	0.1629	0.1420	0.1403	34
Lithuania	0.1156	0.1256	0.1255	0.1426	0.1348	17
Hungary	0.1701	0.1127	0.1120	0.1031	0.1003	−41
Poland	0.1341	0.1444	0.1343	0.1475	0.1548	15
Romania	0.1031	0.1303	0.1358	0.1459	0.1536	49
Slovenia	0.1401	0.1589	0.1634	0.1448	0.1662	19
Slovakia	0.1520	0.1506	0.1577	0.1686	0.1668	10
CEE (average)	0.0113	0.0122	0.0127	0.0127	0.0129	10
EU-27	0.1725	0.2083	0.2170	0.2134	0.2192	27

Source: self-reported data based on Eurostat data.

The electric energy market in the EU is highly competitive. Yet, the share of the biggest producer in the markets of particular member states is strongly diversified (Figure 3). In Latvia, Croatia and Estonia the main energy supplier has a minimum of 70% domestic market share (no data available for Bulgaria). On the other hand, in Poland the biggest electric energy producer supplies only 11.82% of deliveries (less than a half), which makes this market the most competitive, measured by the degree of concentration.

The key political dimension of electric energy markets in particular CEE countries is protecting the energy security of their domestic economies. Energy security remains a strategic element of state policies in a volatile market environment. Countries of the region take great care to ensure the security of their fuel and energy supplies at acceptable prices and deem it crucial for the health of their economies. Until recently, these countries have perceived their energy security in terms of the energy resource deposits they held and used for producing also electric energy. Both in Poland and the Czech Republic a strong attachment to own coal deposits is still clearly visible because they are viewed as a foundation for eclectic energy production. Coal blocks were maintained for years due to high imports of competitive coal from Russia. This trend will most certainly be reversed as a result of Russia's aggression on Ukraine and the planned embargo. A realistic perspective for increasing energy security in terms of producing eclectic energy means focusing on further development of RES, as well as hydrogen technologies which have for some time now become a remedy for the lack of controllability of key renewable energy sources such as wind and solar power in the energy systems of CEE and the entire EU [Wojtkowska-Łodej, Nyga-Łukaszewska, 2019, pp. 91–110]. This approach is encouraged by EU policies and the currently conducted work of the European Commission aimed at significantly accelerating the energetic transformation (e.g. Fit for *55* package). According to the presently adopted proposals, the future scale of emissions should be cut by at least 61% by 2030 (originally the target was 43%) as compared to 2005. A further reduction in the available CO_2 emission permits at the rate of 4.2% annually is also provided for, which is almost two times faster than in 2021. Additionally, some changes in the mechanism of the market stability reserve are planned, which will help absorb the excess of permits even more intensively. Implementing this scenario will most probably mean a further rise in the prices of CO_2 emission permits which will lead to higher prices of electric energy in the upcoming years [Księżopolski, Maśloch, Kotlewski, 2021, p. 331; NBP, 2022].

Figure 3. Share of the biggest electric energy producer in CEE in selected years (%)



Source: self-reported data based on Eurostat data.

Summary

The conducted empirical analysis confirms there exists a correlation between energy prices and inflation in CEE countries. Particularly, a significant statistical causal relationship was identified between the prices of energy resources such as crude oil, natural gas or coal and the inflation rate. CEE economies still remain strongly dependent on fossil fuels, which results from historical conditions, as well as, to a lesser degree, their local deposits of some of the energy resources (e.g. oil in Romania, coal in Poland and the Czech Republic).

In the course of this study it was also diagnosed that there exists a strong causal relationship between the prices of CO_2 emission permits and the inflation rate fluctuations. Emission allowances constitute an indispensable cost element which needs to be taken into account while using fossil fuels. A correlation between electric energy and the inflation rate was also identified; it is observable with a certain delay (of one year), which happens due to administrative issues.

It may be expected that the price fluctuations of primary energy carriers, CO_2 emission permits and electric energy will also affect inflation levels in the foreseeable future. The effects of energy price rises may, on one hand, result in lower competitiveness of companies in the region, but on the other, become a catalyst for change aimed at saving energy and undertaking pro-efficiency activities as well as driving investments into renewable energy sources.

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ENERGY SECTOR IN TIMES OF PRICE SHOCKS AND HYBRID WARFARE

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Abstract

Russia's aggression on Ukraine and the aftermath of the COVID-19 pandemic have caused major energy price shocks. The chapter analyses geostrategic conditioning of the current situation on the European energy market, with special focus on CEE countries, and assesses how these factors affect government policies, corporate operations and infrastructure development.

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The aim of this study[1] is to present the changes which have taken place in the energy sector in CEE since the last SGH report and Economic Forum (2021) until the end of April 2022. The core of these analyses is defining the changing dynamics of the existing trends and possible new shifts in this area. As the study was conducted, Russia attacked Ukraine (24 February 2022), which only confirmed the significance of geostrategic factors for the energy sector and solidified a thesis formulated in the last report that the risk of a hybrid warfare was increasing [Księżopolski, Maśloch, Kotlewski, 2021, p. 331]. The war in Ukraine caused a reaction from the countries of the Euro-Atlantic Partnership in the form of a military, economic and political assistance. The scope of this help varies, however the countries of NATO and EU have been striving to keep their actions consistent. On the other hand, NATO and EU responded to the Russian aggression and denial of borders established in Europe after WWII by waging an economic war on Russia by imposing export, import and investment sanctions [Księżopolski, 2011]. To this date (June 2022), six sanction packages with a direct and indirect impact on energy markets (coal, crude oil and natural gas) have been implemented. These measures triggered Russia to respond with halting gas supplies to Poland and other countries. High dynamics of change and lack of statistical data revealing the effects of the economic war between Russia and the Euro-Atlantic countries seriously constrain the ability to assess their impacts on energy markets. First analyses of these changes can be found in the relevant literature [OECD, 2022; IEA, 2022d]. They conclude that the aggression of Russia on Ukraine certainly exacerbates price shocks on the market as well as intensifies the hybrid warfare fought by Russia.

1 Our authors' team does not represent a uniform point of view on all conclusions and theses.

In the study we have also outlined a rising significance of the renewable energy development (RES), which is also a tool of overcoming economic consequences of the pandemic. The available data allowed us to focus on the analyses of the energy market prices, their consequences for the sector and further development of RES, as well as on the condition and development of the energy infrastructure and actions taken by governments and companies in CEE when faced with Russia's aggression on Ukraine.

The CEE countries included in the study are EU member states (Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Romania, Bulgaria, Slovenia, Croatia and Hungary), and from outside of the EU (Ukraine). The study intends also to account for smaller countries like Moldova, Monte Negro, Bosnia and Herzegovina or Kosovo, depending on the data availability.

The study uses desk analysis data included in reports, government documents, financial reports of companies, and data from Eurostat and International Energy Agency. The time-lag method [Grabiński, 1988] was also used to analyse the gap between CEE countries and the reference object. The tool had been previously applied for the study of the Visegrad Group [Księżopolski, Maśloch, 2021].

Preparing for the war

A key circumstance recently affecting the energy sector and the economies of European countries, including CEE countries, had been war preparations conducted by Russia for many years before the aggression. They gained momentum after 9 June 2021 and the visit of president Joe Biden in Europe. The effect of Russia using energy resources as an economic and political tool before the attack on Ukraine was the gas market price crisis. In the last quarter of 2021 the prices of this resource were at 85–183 EUR/MWh (TTF), compared to the same quarter of 2020 when they amounted to 13–17 EUR/MWh (TTF). The crisis was perpetrated by two factors: a significant increase in the demand for natural gas resulting from the post-pandemic rebound and a slump in spot supplies from Russia. Russia's public message was about its necessity to replenish own gas stocks, accompanied by a pledge to deliver on the long term contracts (after cutting off gas supplies to some European countries in spring 2022 this can no longer be trusted). This policy, presenting Russia as a reliable partner, has always been a key lever in Russia's narrative and its misinformation of nations and governments worldwide. In an attempt at counteracting Russia's assault on Ukraine, the Unites States publicly broadcast information on preparations to the attack. This made markets restless and caused high price volatility. Russian policy resulted in much lower gas stocks held in the EU than could be needed to meet the usual winter peak

(2021/2022) in demand for this resource. The goal of such actions was to discourage European countries from imposing economic sanctions on Russia after the planned aggression had started. Simultaneously, they were a form of blackmail towards Germany, intended to force the exploitation of Nord Stream 2 and approval of Russia's economic and political dominance over Ukraine. Natural gas price volatility was spilled over to other fuels, such as crude oil and coal, completely transforming the market environment for companies both in CEE and in the EU at large.

Until the aggression of Russia on Ukraine (24 February 2022), the European climate and energy policy was conducted based on the path dependency principle, according to which previous decisions determined future goals [Goodin, Tilly, 2006; Pierson, 2000].

In mid 2021 (14 June) the European Commission put forward many regulatory proposals (Fit for 55 package) aimed at achieving the climate neutrality goal in EU by 2050, with an interim goal of reducing CO_2 emissions by 55% by 2030 [European Council, Council of the European Union, 2022]. The solutions provided for in the package include over a dozen legislative initiatives involving, among others, trade in CO_2 emissions – particularly important from the Polish perspective, renewable energy sources, energy efficiency, development of infrastructure (car emission standards etc.), and they are worked on using the procedure of co-decision between the European Commission, Parliament and Council. It was only Russia's military aggression that made EU countries and institutions review their goals and measures. The path of developing RES aimed at reducing the dependence on energy resources imported into the EU does not seem threatened. Tapping into RES can visibly enhance countries' energy security [Księżopolski, 2017, 2019; Księżopolski, Pronińska, Sulowska, 2013; Pronińska, Księżopolski, 2021], yet recognising natural gas as an interim resource in order to deliver on this goal cannot be sustained, at least not in the nearest 2–3 years and was previously questioned by the authors of this publication [Księżopolski, 2020]. Thus, there appear two possible options which will be implemented jointly: developing gas import infrastructure – mostly LNG, and searching low-cost energy storage technologies including the development of hydrogen technologies.

Russian aggression on Ukraine proves that the EU as a whole is not prepared to impose import sanctions on the Russian crude oil and natural gas. It is a consequence of ignoring studies, analyses and opinions, particularly these flowing from Poland and other CEE countries, which have long indicated excessive dependence of the entire EU on the Russian gas. Failure to conduct any analysis of the presented scenario proposing zero gas imports from Russia in *Winter Supply Outlook* of October 2021 may serve a good example here [ENTSOG, 2021]. Such solution variants have been for many years a focus of interest for CEE countries, as demonstrated by the strategic game assuming a complete halt of gas supplies from Russia conducted during the Economic Forum of 2017 [Księżopolski, 2017].

Russian aggression on Ukraine has made it painfully clear that some countries, particularly Germany, committed a strategic blunder when allowing an excessive share of the Russian gas imports. The German policy and its influence on the European Commission was followed by the adoption of a rule, according to which gas was to become an interim fuel of the energy sector transformation. This large share of the Russian gas in Germany and the entire EU was not accompanied by any strategic thinking which should have provoked more investment in the infrastructure offering a better possibility of easily switching to other import options. It is not only about LNG terminals, but also inter-system connections, such as these between Spain and France. An immediate result is, even though Spain is able to increase its gas imports up to 17 bn m^3, that other European countries cannot use this opportunity. Taking into account that the total imports of gas from Russia to EU in winter between October 2022 and March 2023 will amount to 109 bn m^3 (assuming long term agreements will be delivered on, based on business as usual – BSU rule) [Aurora Energy Research, 2022], the above Spanish option would be able to replace about 15% of gas imports from this country. As a response to the Russian aggression on Ukraine, on 8 March this year the European Commission has put forward a draft plan [European Commission, 2022] of attaining energy independence, mostly from the Russian gas, by 2030.

CEE countries have, for a long time now, been expanding their potential for gas supply diversification, switching to other import options than Russia. Particularly intensive actions were taken by Poland which in 2015 completed the construction of an LNG terminal and invested in a gas connection with Lithuania (GIPL gas pipe) with a capacity of about 2 bn m^3 of gas, which allows to use deliveries from a floating terminal in Klaipeda, as well as planned to finish the construction of the Baltic Pipe by October 2022, which will allow for the import of 10 bn m^3 of the Norwegian shale gas. Both ventures have been put on the list of Projects of Common Interest – PCI, co-financed by the EU. After launching the Baltic Pipe and extending the LNG terminal to the target capacity of 7.5 bn m^3, the sum of all gas import options (apart from Germany and the south of Poland connections with Ukraine, Slovakia and the Czech Republic) will amount to 19.5 bn m^3, which along with the domestic deposits of about 4 bn m^3 will be able to meet the current Polish demand for gas, accounting for 21.4 bn m^3 (data for 2020). Another source of gas supplies will be the floating LNG terminal in Gdańsk, the installation of which is planned for 2025. As a result, Poland, thanks to its infrastructural connections with other CEE countries – Slovakia, the Czech Republic and Ukraine, will become an important local gas hub, responsible for bringing energy security to the region.

Despite significant progress in diversifying gas sources, CEE countries will not be resilient to the negative effects of price volatility of resources on key macroeconomic indicators, particularly inflation, interest rate stability and currency exchange rates. The consequences of high and volatile prices of oil and gas are crucial social factors and will inspire an ongoing public debate about the costs of energy policies in CEE countries.

EU Emissions Trading System (EU ETS)

Recognising tighter climate policies and RES development as ways of overcoming the pandemic caused the prices of CO_2 emission permits to continue rising in 2021. Average emission permit price amounted to 54 EUR per one tonne of CO_2 (an increase of 117% on 2020), with the maximum price per one tonne of CO_2 at 97 EUR. It should be highlighted that in the report published in March 2022, the European Securities and Markets Authority (ESMA) indicated that there were no abnormal events on the market of traded CO_2 emission permits, which persuaded the European Commission that there was no need to reform this key and fundamental climate policy tool [ESMA, 2022].

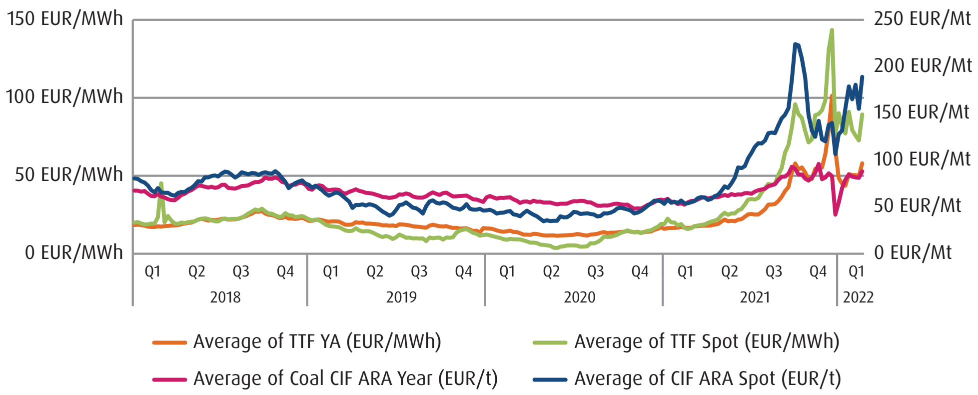
Figure 1. Price fluctuations of CO_2 emission permits (EUR/t CO_2)

Source: Market Observatory for Energy, DG Energy [2022a].

Information of Russia attacking Ukraine resulted in prices slumping to 58 EUR per one tonne of CO_2 (7 March 2022). Insecurity about the future of the climate and energy policy, as well as the future of the entire Europe triggered the abovementioned market reaction. High price fluctuations (Figure 1) present a great challenge to companies and governments, particularly due to price shocks which are very hard to accommodate and which create other disruptive circumstances following Russia's aggression on Ukraine. Currently, under Fit for 55 package negotiations, there continues a vivid debate on reforming EU ETS, with Poland actively participating in the discussion. In the meeting of 20 April 2022, ITRE Commission of the European Parliament adopted an amendment proposed by Jerzy Buzek, aimed at excluding financial institutions from ETS system, which is expected to prevent speculative price hikes on emission permits. Other disputed proposals concern the introduction of a price corridor or amending the regulations on market interventions in the situation of high price volatility. The work on these solutions is under way, and the final shape of the directive will be known probably next year, after the co-decision procedure is completed. On 22 June 2022 the European Parliament voted for the exclusion of financial entities from the market of EU ETS, which may decrease price volatility on this market and is eventually likely to drive prices down.

Apart from changing prices on the market of EU ETS which fell after Russia attacking Ukraine and until April have not returned to the highest levels of 2021 (although since mid-March they have been at a very high level of 70–90 EUR/MWh), the market of resources has also shown a similar price volatility. During the time of the pandemic we saw low or even negative (in US) prices of crude oil [Connolly, Handson, Bradshow, 2020], the trend which has recently been reversed (Figure 2).

Figure 2. Weekly changes in prices of natural gas and coal on spot and futures markets in one-year period according to TTF (EUR/MWh) and ARA (EUR/t) indices



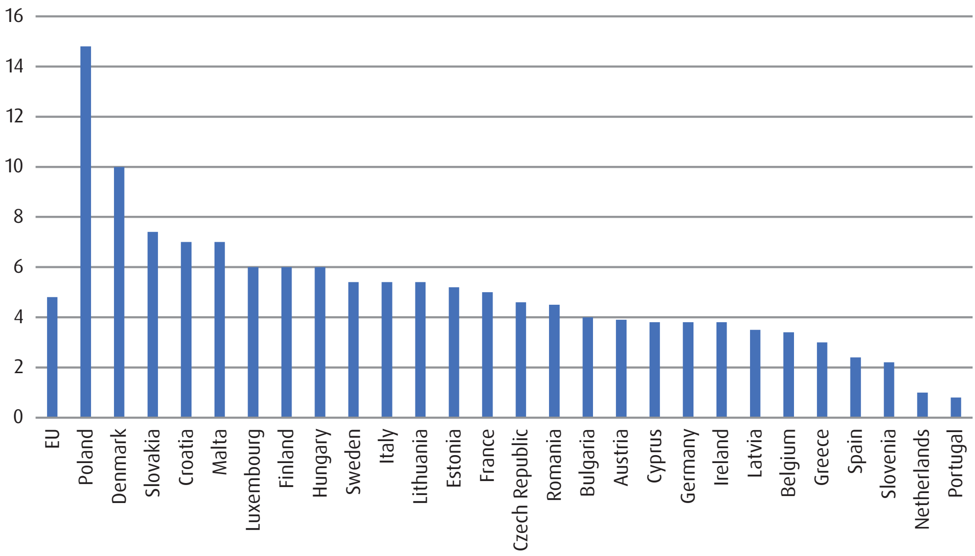
Source: Market Observatory for Energy, DG Energy [2022a].

Price changes on the energy market and questions about ways of energy transformation

Effects of the Russian preparations for attacking Ukraine and starting a war in the light of energy markets

A 2021 rebound from the crisis inflicted by the pandemic produced very high levels of electric energy, gas and oil consumption. The level of consumption of electric energy bounced back to the volumes from before the pandemic in 2019. The highest spikes in demand for electric energy in 2021 were recorded in Poland (of 15%), Denmark (of 10%) and Slovakia (of 7%) with an average increase in the consumption of electric energy in EU at 5%.

Figure 3. Annual changes in electric energy consumption in EU in 2021 (%)

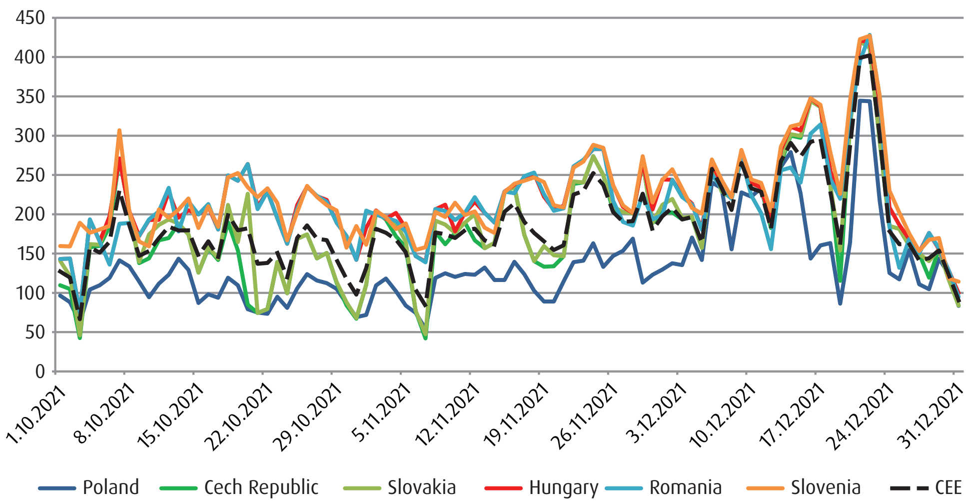


Source: Market Observatory for Energy, DG Energy [2022a].

Increase in the demand for electric energy to the level from 2019 with simultaneous turbulences on the gas market, which will be discussed later, caused a dynamic rise in the prices of electric energy in the countries with a high share of gas in their electric energy production. It was the hardest felt by France, Spain and Portugal where the prices of electric energy grew by even 425%, amounting to 221.3, 210.8 and 210.9 EUR/MWh respectively. In the report of 2021 we specified the CEE countries with a high share of gas in the production of electric energy and expressed a negative assessment of the situation [Księżopolski, Maśloch, Kotlewski, 2021, pp. 308–309] – from among the countries of the region with a share of over 25% (Lithuania, Latvia, Croatia, Hungary) only in the latter two prices rose to 223 and 219 EUR/MWh respectively.

In Poland, the biggest electric energy market of CEE, their level reached 133.5 EUR/MWh, which places it much below the forecasts of the European Power Benchmark projecting 194 EUR/MWh in Q4 of 2021. CEE countries in this respect behaved in a highly diversified way. The countries from the south of the region saw prices close to 200 EUR/MWh (Croatia – 223 EUR/MWh, Romania – 212 EUR/MWh, Bulgaria – 205.7 EUR/MWh, Hungary – 219 EUR/MWh), the Czech Republic was in the interim group (183.2 EUR/MWh) as well as Slovakia (189.5 EUR/MWh), the lowest prices were recorded in the northern and central part of the region (Poland – 133.5 EUR/MWh, Lithuania – 146.4 EUR/MWh, Estonia – 141.7 EUR/MWh). In Ukraine it was 90.2 EUR/MWh. The above given data refer to Q4 of 2021 and the average daily price of electric energy on the wholesale market (baseload).

Figure 4. Average daily electric energy prices on the day-ahead market in CEE (EUR/MWh)



Source: Market Observatory for Energy, DG Energy [2022a].

On the electric energy day-ahead market in Q4 of 2021 a dynamic rise in prices and liquidity was noted (Figure 4). It should be noted that, similar to the abovementioned spot market, these prices were higher in CEE countries with a high degree of dependence on gas (Hungary) than in these which based their energy mix on coal (Poland). The premium for Poland on the day-ahead market amounted to 53 EUR/MWh in Q4 of 2021. In this case, even high prices of the CO_2 emission permits and rising coal prices were not as acutely felt as increasing gas prices and uncertainty concerning meeting the demand for this resource in winter months of 2022. An important element mitigating the effects of rising resource prices on the electric energy day-ahead market in Poland was the execution of future contracts for the deliveries of coal, which alleviated the impacts of changes in resource prices across the world. Most certainly, expanding in June 2021 of the day-ahead power market coupling in the Czech Republic, Slovakia, Hungary and Romania with multi regional coupling on the border with Poland, Germany and Austria caused the easing of the price pressure in these countries.

Table 1. Prices of electric energy supplied to households in selected European countries in 2nd half of 2020 and 1st and 2nd half of 2021 (EUR/kWh)

Time period / Country	2nd half of 2020	1st half of 2021	2nd half of 2021	Deviation from EU average (%)	Change in 2nd half of 2021 versus 1st half of 2021 (%)
EU	0.0476	0.0411	0.0546	no data	32.8467
eurozone	0.0504	0.0430	0.0578	5.8608	34.4186
Bulgaria	0.0290	0.0306	0.0639	17.0330	108.8235
Czech Republic	0.0461	0.0463	0.0486	−10.9890	4.9676
Germany	0.0471	0.0435	0.0474	−13.1868	8.9655
Estonia	0.0305	0.0325	0.0587	7.5092	80.6154
France	0.0536	0.0489	0.0569	4.2125	16.3599
Croatia	0.0302	0.0300	0.0318	−41.7582	6.0000
Latvia	0.0214	0.0229	0.0340	−37.7289	48.4716
Lithuania	0.0218	0.0201	0.0309	−43.4066	53.7313
Hungary	0.0243	0.0241	0.0240	−56.0440	−0.4194
Poland	0.0336	0.0301	0.0380	−30.4029	26.2458
Romania	0.0269	0.0266	0.0399	−26.9231	50.0000
Slovenia	0.0384	0.0382	0.0415	−23.9927	8.6387
Slovakia	0.0400	0.0342	0.0353	−35.3480	3.2164
Northern Macedonia	0.0384	0.0414	0.0483	−11.5385	16.6667
Serbia	0.0311	0.0305	0.0310	−43.2234	1.6393
Bosnia and Herzegovina	0.0295	0.0274	0.0311	−43.0403	13.5036
Moldova	0.0242	0.0225	0.0435	−20.3297	93.3333
Ukraine	0.0215	0.0228	0.0228	−58.2418	0.0000

Note: for Ukraine in the 2nd half of 2021 the same data were used as in the 1st half of 2021 (the second column from the left, two places after the decimal point).

Source: self-reported data based on Eurostat data.

Increase in the prices of electric energy has been also observed in households. It is very crucial for their purchasing power and the inflation processes, on one hand resulting from the application of measures aimed at mitigating negative economic consequences of the pandemic, on the other – from the inflation triggered by the Russian politics (Table 1).

In the case of households, a divergence from average EU prices may be observed, and only in Bulgaria and Estonia these prices have been above average. Therefore, in most CEE countries the prices of electric energy supplied to households were lower in the 2nd half of 2021 than the EU average, and the biggest divergence was recorded in Hungary and Ukraine (56% and 58% respectively). Unfortunately, this situation was also accompanied by rises in electric energy prices for households, amounting to as much as 80% (in Estonia). Only in Hungary this price was slightly lower, which was due to government subsidies. To recap, despite the fact that the prices of electric energy supplied to households were lower in the 2nd half of 2021 than the EU average, citizens of most CEE countries experienced increased costs of electric energy. It should be observed that electric energy prices for households are affected both by the fiscal policies of particular countries, including taxes and environmental charges, as well as by specific public policy measures (during the economic war with Russia frequently employed by various countries, such as the anti-inflationary shield in Poland), which significantly impacts on the presented data.

Table 2. Prices of electric energy supplied to other energy consumers than households in selected European countries in 2nd half of 2020 and 1st and 2nd half of 2021 (EUR/kWh)

Time period / Country	2nd half of 2020	1st half of 2021	2nd half of 2021	Deviation from EU average (%)	Change in 2nd half of 2021 versus 1st half of 2021 (%)
EU	0.0820	0.0859	0.1032	no data	20.14
eurozone	0.0842	0.0888	0.1061	2.81	19.48
Bulgaria	0.0833	0.0842	0.1761	70.64	109.14
Czech Republic	0.0713	0.0739	0.0758	−26.55	2.57
Germany	0.0885	0.0908	0.0967	27.57	6.50
Estonia	0.0750	0.0834	0.1403	35.95	68.23
France	0.0754	0.0850	0.0810	−21.51	−4.71
Croatia	0.0878	0.0881	0.0998	−3.29	13.28
Latvia	0.0839	0.0849	0.1191	15.41	40.28
Lithuania	0.0901	0.0932	0.1294	25.39	38.84
Hungary	0.0833	0.0818	0.0998	−3.29	22.00
Poland	0.0784	0.0731	0.0685	−33.62	−6.29
Romania	0.0848	0.0824	0.1130	9.50	37.14

cont. Table 2

Country \ Time period	2nd half of 2020	1st half of 2021	2nd half of 2021	Deviation from EU average (%)	Change in 2nd half of 2021 versus 1st half of 2021 (%)
Slovenia	0.0809	0.0757	0.0812	−21.32	7.27
Slovakia	0.0972	0.0929	0.0999	−3.20	7.53
Montenegro	0.0513	0.0773	0.0527	−48.93	−31.82
Northern Macedonia	0.0756	0.0752	0.1225	18.70	62.90
Serbia	0.0731	0.0702	0.0774	−25.00	10.26
Bosnia and Herzegovina	0.0702	0.0719	0.0695	−32.66	−3.34
Kosovo	0.0641	0.0635	0.0649	−37.11	2.20
Moldova	0.0718	0.0633	0.0640	−37.98	1.11
Ukraine	0.0558	0.0595	0.0595	−42.34	0.00

Note: for Ukraine in 2nd half of 2021 the same data were used as in 1st half of 2021 (the second column from the left, two places after the decimal point).

Source: self-reported data based on Eurostat data.

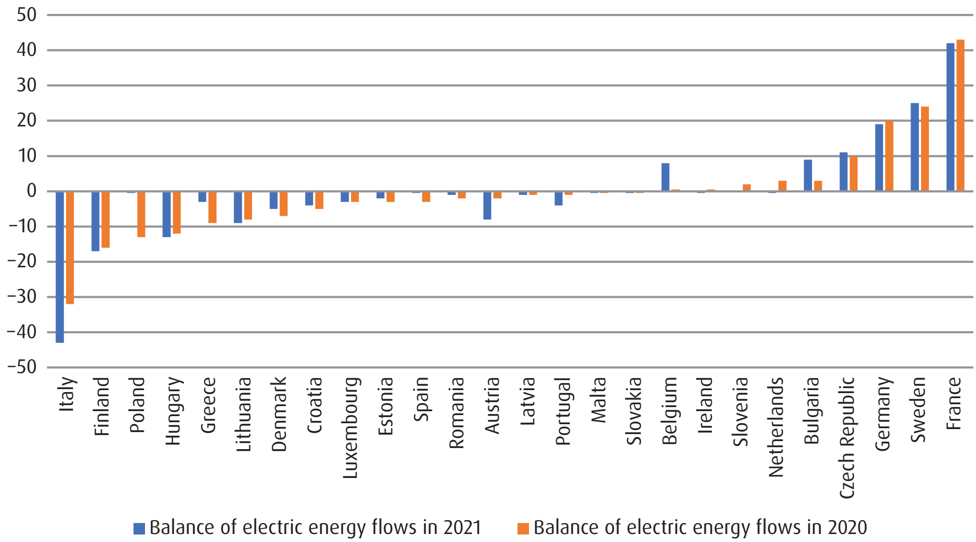
Data on the average prices of electric energy supplied to consumers other than households in the 2nd half of 2021 as compared to the 1st half of 2021 indicate that most CEE countries were characterised by lower prices than the EU average (more in Table 2). It applies to Poland (a difference to average was 36%), the Czech Republic (26%) and Slovenia (21%), higher prices were seen in the Baltic countries, and significantly higher in Bulgaria, where this rise reached 70% (Table 2). At the same time prices of electric energy supplied to consumers other than households increased in Germany by 27.5%.

As mentioned before, after the pandemic the demand for electric energy increased in all CEE countries. Nevertheless, the pandemic period (until the end of 2020) did not produce, apart from Poland, major changes in the exports and imports of electric energy. Poland, Hungary, Lithuania, Estonia, Romania, Latvia and Slovakia showed deficit in this period, only Slovenia, Bulgaria and the Czech Republic recorded surplus electric energy production. Poland, being a large net importer in 2020, in 2021 became a country with almost equal balance of exports and imports (Figure 5). For Baltic countries the difference between Q4 of 2021 and Q4 of 2020 was negligible (3.5 TWh).

In the second quarter of 2021 there was a considerable rise in the consumption of gas in the EU as compared against the analogical period of 2018–2020 (Figure 6).

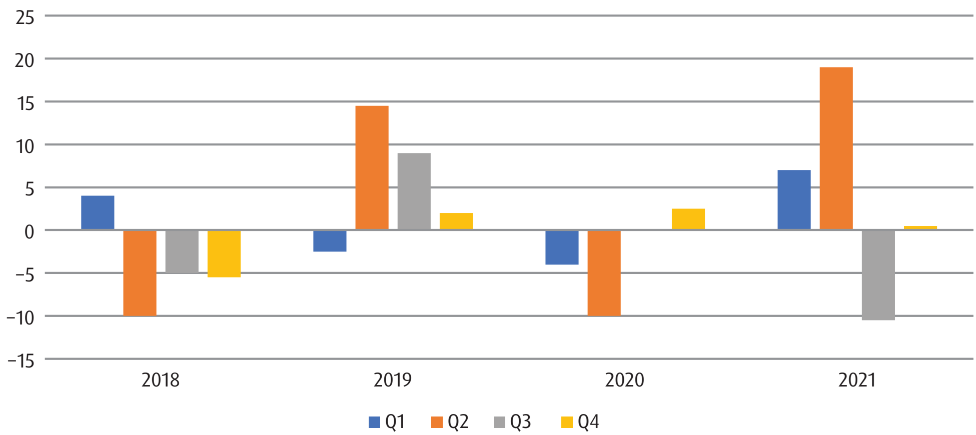
In this respect CEE countries did not diverge from the rest of EU. In Q4 of 2021 gas consumption fell in Lithuania by 18%, i.e. by 0.1 bn m^3. In other CEE countries gas consumption increased by 25%, i.e. 0.3 bn m^3, in Slovakia to 17%, i.e. 0.02 bn m^3, in Estonia. Apart from Russian politics, the level of prices was driven by increasing gas consumption of the leading consumers in EU. In Germany gas consumption reached the level of 94 bn m^3, which is 5% (4 bn m^3) gas more than in the same period last year, in Italy it was 76 bn m^3 (a rise of 7%, i.e. of 5 bn m^3), in the Netherlands – 2 bn m^3 (a rise of 4%), in France – 41 bn m^3 (a rise of 6%). Also in Spain the consumption of gas was higher by 6%. High prices at the end of the year caused a surge in the costs of gas imports (Figure 7).

Figure 5. Exports and imports of electric energy in EU member states in 2021–2020 (net, TWh)



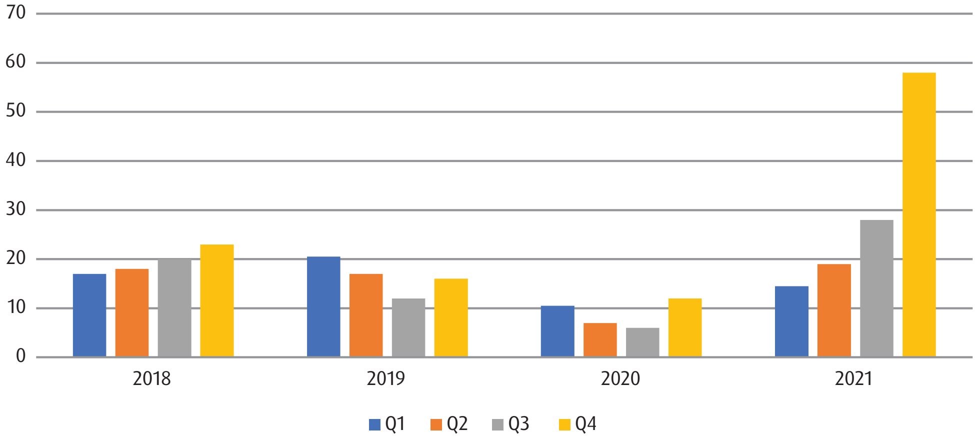
Source: Market Observatory for Energy, DG Energy [2022a].

Figure 6. Annual change in gas consumption in a quarterly division in EU (%)



Source: Market Observatory for Energy, DG Energy [2022b].

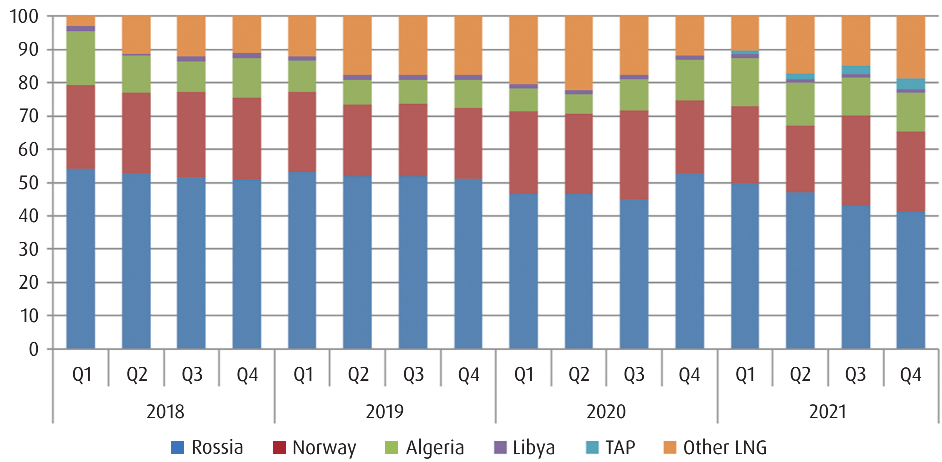
Figure 7. Estimated quarterly costs of gas imports to EU (bn EUR)



Source: Market Observatory for Energy, DG Energy [2022b].

Costs of gas imports in Q4 of 2021 surged to 58 bn EUR, the highest quarterly level in eight years. As compared on Q4 of 2020, these costs jumped by 391%. Comparison of 2020 and 2021 data indicates that the costs of imports rose from 35.9 bn EUR to 120.8 bn EUR, 41.5 bn EUR of which went to Russia for the gas transferred via gas pipelines. On top of that, there are also transfers resulting from Russia's presence on the LNG market, accounting for 35.8 bn EUR for the entire EU in 2021.

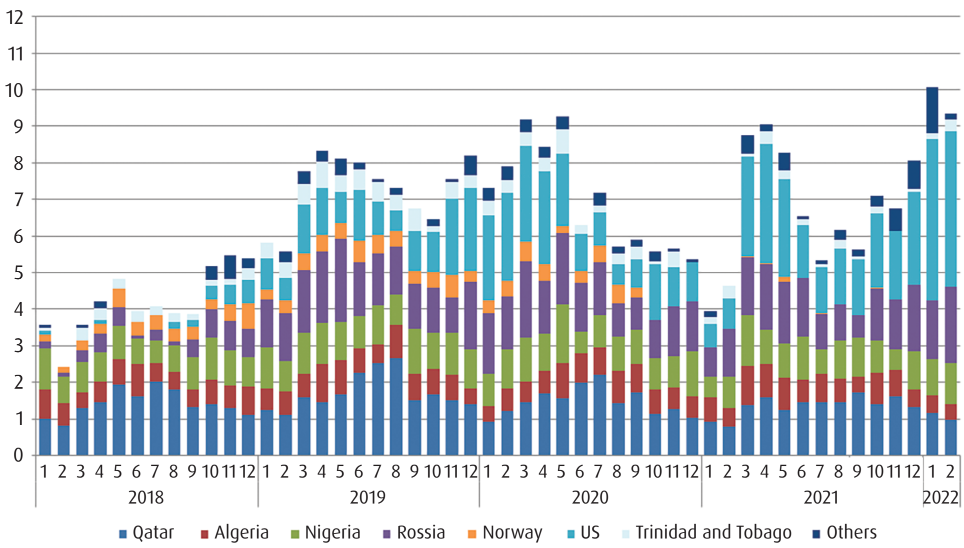
Figure 8. Directions of EU gas supplies (%)



Source: Market Observatory for Energy, DG Energy [2022b].

It can be clearly seen that in Q4 of 2021 Russia reduced its gas exports via gas pipeline systems, delivering solely on long term contracts, nevertheless Russia's share in this period was at 37%. Between Q4 of 2021 and Q4 of 2020 imports of gas from Russia slumped by 24%. Russia's preparations for the war with Ukraine became quite apparent at that time. Firstly, gas transit through Ukraine fell in Q4 of 2021 as compared on Q4 of 2020 by 36%, i.e. from 4.6 bn m^3 to 3 bn m^3 per month. In January 2022 gas transits through Ukraine accounted for 1 bn m^3, and in February edged up a little to 1.5 bn m^3. In Q4 of 2021 a significant slump in gas transits through Belarus to the EU was noted, it was 56% lower than in the same period last year. In November and December these transits amounted to less than 1.5 bn m^3 of gas, the lowest level in seven years. On the other hand, the amount of gas supplied through Nord Stream 1, directly connecting Russia and Germany, was similar to the Q4 of 2020 (5 bn m^3 of gas per month). It means that Nord Stream 1 has become the main source of gas supplies for EU, covering in Q4 of 2021 49% of all gas imports from Russia.

Figure 9. Structure of gas imports to EU (bn m^3)



Source: Market Observatory for Energy, DG Energy [2022b].

In the situation when gas and return to nuclear energy are used as tools for exerting pressure on CEE, and more widely on the EU at large, in Q4 of 2021 a dynamic surge in LNG gas imports (of 33%) took place. Comparison of particular months of 2021 and 2020 indicates that this dynamic in the monthly perspective amounted to:

27% in October, 19% in November, 53% in December, and over 100% in January and February. In Q4 of 2021 EU imported 23.3 bcm of gas. In the entire 2021 EU countries imported 80 bcm of gas, which is less than in 2020 (84 bcm). In 2021 LNG gas supplied to the EU came from the US (22.3 bcm, i.e. 29% of total imports), Russia (16 bcm), Qatar (16.3 bcm), Nigeria (11.2 bcm) and Algeria (8.5 bcm).

Concluding about the geopolitical factors resulting from the Russian aggression on Ukraine and a long-time use of gas and oil supplies as tools of political influence and destabilisation of CEE, as well as other EU countries, it must be considered what measures the EU should apply to deliver on its energy and climate policy goals. In our 2021 report we stressed that the pandemic had not diverted any trends observable in this respect [Księżopolski, Maśloch, Kotlewski, 2021, pp. 299–300]. It is virtually difficult to forecast further developments in this area due to very high dynamics of international events, the situation in Ukraine and currently observable shifts on the energy market. The most probable scenario seems to be that these tools will be changed and the pace of implementing this policy will accelerate. It should be expected that more focus will be placed particularly on the initiatives aimed at eliminating the use of gas in energy production by faster development of renewable energy sources, as well as on efficiency boosting initiatives, tighter integration of transmission grids [Droste-Franke et al., 2012], energy storage development [IRENA, 2017], and temporary increase in the use of coal.

Geostrategy of the energy sector

Infrastructure problems and a strong price stimulus have affected the prices of electric energy and undermined the future of gas as an interim fuel in the climate and energy policy. The current situation shows that the very diversification of supplies is not sufficient to ensure economic security of countries which tends to crumble when affected by price impulses.

A decision of Euro-Atlantic countries to offer military, economic and humanitarian support to Ukraine and cripple aggressor's potential gave rise to a debate over imposing economic sanctions on the imports of crude oil, natural gas and coal from Russia. Some countries, like the US and Canada have quickly implemented import bans on energy resources. Some EU countries did not adopt such bans despite the statement of the European Parliament calling for sanctions. Many CEE countries, particularly Poland, are very actively persuading other EU states to adopt boycott measures. Poland has gained a significant strategic advantage over other "old" EU countries, particularly Germany, by properly assessing geostrategic risks and developing an infrastructure allowing for a major diversification of gas import directions. It may grow Poland's importance in the region and ensure energy security to some EU countries. Lack of clear statements from all EU countries concerning gas imports from Russia causes increased risk to the entire sector, at the same time cutting down on the time needed to make the necessary adjustments before winter 2022/2023. There have been numerous reports on the possibility of quitting gas imports from Russia, recommending ways and the best time to conduct such a change so that the negative consequences to EU countries will be minimised. Usually, there are two types of actions involved in the process – on the supply and the demand side. Ensuring higher supply of gas from other sources than Russia requires increased LNG imports (Germany wants to rent four floating LNG terminals, two of them still in 2022) and more gas output from extraction in EU countries and Norway (difficult to achieve in a short term). Actions on the demand side involve short term behavioural changes (e.g. turning down temperature in buildings heated with gas) as well as medium and long term investments permanently reducing demand for gas, such as developing renewable energy sources and energy storages, investments in thermo-modernisation of buildings and electrification of district heating (heat pumps) etc. More controversial proposals include increasing coal use in energy production (which is happening anyway due to price relations) and extending the life of some nuclear power plants (the Belgian government decided to maintain 2 out of 7 GW of nuclear power until 2035; this has not changed the decision of the German government to shut down the last three reactors with a joint power of 4 GW at the end of 2022). In the report of 3 March 2022 Aurora Energy Research [2022] points out to the necessary steps on the supply and demand side in order to obtain more gas for the EU[2]. They are to ensure a balanced supply and demand for gas in the EU. The situation for crude oil and coal is much better – the existing infrastructure guarantees supplies of these resources to all consumers. Should there be a ban on the imports of Russian crude oil, Poland, with the existing infrastructure, will be able to supply this resource to the refineries in Schwedt and Leuna in the eastern part of Germany which need a total of 22 bn barrels of oil, when the port in Rostock has the handling capacity of 9 bn barrels [find more: IEA, 2022a, 2022b]. In the 6th package of sanctions (of 2 June 2022) a ban on the purchase, imports and transfer of crude oil

2 According to analysis, the missing 109 bcm of gas from Russia may be supplied by maximising the imports of LNG, which can provide 24 bcm of gas, increasing production in Norway (8 bcm), increasing imports from South Africa (7 bcm), raising production in the Groningen gas field (6 bcm), growing production in Great Britain, Poland and Romania (10 bcm) and using 22 bcm of gas currently in storage. This way EU will have 253 bcm of natural gas at its disposal, and the deficit will amount to 33 bcm, which is 11%. Proposed demand side measures are about changing the *merit order* from gas to coal, which will deliver estimated savings of 6 bcm of gas, extending the life of nuclear power plants (5 bcm), maintaining coal power plants (7 bcm), reducing the consumption of gas in households (6 bcm), using heat pumps (1 bcm), making savings in the industrial sector and switching to another type of fuel (10 bcm). These joint actions will generate the demand for gas in EU at the level of 251 bcm.

and some petroleum products was imposed, for the period of six months in the case of oil and eight months for petroleum products. There were some exemptions for the countries which are particularly dependent on these resources, such as Hungary, Bulgaria and Croatia. During the negotiations of the 6th package of sanctions the position taken by Hungary was of special concern, as it undermined the coherence of actions taken by the EU. It raises more concerns about the role of MOL, a chain controlled by the Hungarian government, in the process of consolidation of PKN Orlen and Lotos.

Slashing gas consumption will have severe long and short term implications for the energy sector. Firstly, it will be necessary to maintain some coal power longer than previously planned, which may appear difficult with high CO_2 emission permit prices and other regulations raising installation costs (new BAT/BREF standards). Ultimately, it may force the creation of new rescue mechanisms or streamlining of the existing forms of assistance (strategic reserve, suitable power market configuration). Secondly, management mechanisms are needed in order to maximise the exploitation of the current gas infrastructure. It involves conducting some public intervention and partial withholding of market instruments for about one year. Thirdly, optimal ways of using the resource supply should be designed and it should be sent where there are no cost-effective alternatives. Fourthly, better demand management is necessary (savings, change of fuel). Fifthly, implementing renewable energy sources and efficiency measures on the largest possible scale can help reduce the use of gas in energy and heat production while at the same time develop the power grid and energy storage. The above mentioned measures offer a strong impulse for technological innovation in energy storage and management as well as energy savings and heat technology development.

There are various available methods of substituting gas imports from Russia, however they may require some time to be fully implemented. Mediterranean countries, particularly Italy, may substitute Russian gas with gas imported from Algeria via the existing pipelines driven through the Mediterranean Sea, with their transmission capacity being now extended (apart from pipelines running from Africa through Sicily, transmission plans through Sardinia are also implemented). There exists also a very high potential of increasing gas imports via the pipelines from Norway – this applies particularly to Poland which is currently connected to the Baltic Pipe. Theoretically, the great project of Nabucco pipeline could be revived, under which Turkey and the Balkan countries were to build a large pipeline to import big amounts of natural gas from the Middle East, also Azerbaijan, to CEE countries. Some modifications were also provided for under this plan, such as connecting Poland to this pipeline. Implementing this project could be the most significant strategic initiative, as only the Middle East has gas deposits comparable in size to Russia (or even greater in total, putting the resources of all countries together). The other gas resources must be imported to European countries by sea, which implies the need to build gas terminal infrastructure (some steps have already been taken e.g. in Świnoujście). Implementation of the Polish agenda of launching the abovementioned important gas pipeline (Baltic Pipe), as well as a gas inter-connector between Poland and Lithuania (GIPL), aimed at disrupting the isolation of the Baltic countries' gas market, also an inter-connector between Poland and Slovakia, as part of the European initiative of building the North-South corridor [Gaz-System, 2021, p. 20]. Yet, the plans of developing transmission networks are wider than that and they provide for creating 34 gas transmission pipelines [Gaz-System, 2021, pp. 22–23], not to mention the remaining infrastructure (such as gas compressor stations, system nodes, etc.). The development plans of other countries in the region are actually less ambitious [Eustream, 2021], but their characteristic is too extensive to be included in this study.

On the demand side, there may be also some steps taken to reduce demand for the imported natural gas. Integration of electric energy transmission grids may serve this purpose (sic), because the bigger and more integrated the international transmission grids, the lower the relative demand for peak energy produced in the dedicated gas peaking plants. Demand for gas may be reduced also by abandoning its use in full-load power plants, which is controversial from the point of view of the climate policy, as their competition are traditional coal plants or nuclear plants. Unfortunately, as long as new technologies are not widely spread (particularly the storage of electric energy and its conversion into hydrogen, as well as the elasticity of the demand side), rising significance of wind and solar energy will only mean higher demand for electric energy produced in storage power plants used to balance out fluctuating production in renewable power plants. International integration of gas transmission grids and diversification of natural gas supplies is currently necessary for economic and geostrategic reasons. This inability to completely quit natural gas encourages the inclusion of gas power plants (after meeting numerous strict criteria) in the current European sustainable taxonomy as an interim technology in the process of reaching the future goal of entirely green energy production. According to recent optimistic forecasts, demand for natural gas in Europe will be rising until 2030, and then will most probably start falling as a result of substitution with electric energy and hydrogen derived from zero-emission sources [ENTSO-E, ENTSO-G 2021, pp. 15–23]. This situation may, however, be quite radically reversed as a result of the Russian aggression. Following recent forecasts, demand for gas in Poland will keep rising until 2035 [Gaz-System, 2021, p. 15] from the level of 19.1 bcm (215 TWh) to 34.7–37.5 bcm (390–421 TWh in equivalent energy units), then will level out, as the effects of the energy transformation are revealed. These forecasts may also appear to be largely overestimated.

The geostrategic factor has an important effect also on the actions taken by countries' governments. Some of them, faced with rising inflation caused by the consequences of the pandemic and high energy resource prices decided to reduce fiscal burdens on fuels (VAT and excise reduction – in Poland), or to freeze various forms of regulatory gas and electric energy price hikes for households. This trend is becoming a widely recognised standard of action, yet along with falling resource prices we may expect such mechanism to be abandoned.

Russian aggression has made it very clear that the energy infrastructure is one of the key elements of the negative leverage employed by the aggressor. This apparent fact may be more readily recognised by decision-makers who do not make a sufficient use of the potential offered by the renewable energy production and grid decentralisation.

In our last report we pointed out to hybrid threats as vital challenges to the energy sector [Księżopolski, Maśloch, Kotlewski, 2021, p. 331]. The war in Ukraine makes Baltic countries as well as Poland and Romania not only the countries of the eastern flank, but also the front countries which are exposed as potential targets to the next hybrid warfare assaults. Poland's engagement in humanitarian transports to Ukraine and unconditional support by the Polish government and most political parties as well as Polish citizens' active involvement in receiving three million of Ukrainian guests, mostly women, children and the elderly, increase the probability of using such measures against Poland. According to the surveys run by NATO key signs of such actions are misinformation, manipulation and cyber attacks, also sabotage, blocking ports and sea reservoirs (important particularly to MEW). Misinformation is particularly important in the context of overcoming the pandemic and the currently rising inflation, as well as because of the historical heritage (communism and deep infiltration of the political and academic structures). After Russia's aggression on Ukraine the energy and banking sector have undergone such actions, both in CEE and, to a lesser degree, in other EU countries.

The geostrategic effect in the sector has been proven by the studies indicating that RES increase energetic and economic security of countries by decreasing energy dependence on imported resources, faster investment processes, stable costs of the produced electric energy irrelevant of fluctuations in fuel prices (non-existent in most of these technologies) and prices of CO_2 emission permits. These energy sources also do not generate negative impulses for macroeconomic indicators, which cannot be avoided when using imported fossil fuels. In this respect, nuclear energy production is becoming a highly attractive technology for decision-makers due to its lower dependence on volatile nuclear fuel prices and zero-emission characteristic.

Development of RES in CEE

Time delay in RES development in CEE

The study uses the time delay method which is widely applied in creating forecasts and analyses of the energy sector development, particularly the renewable energy sector [Księżopolski, Maśloch, 2021]. A detailed explanation of the time delay method for 2004–2021 in the studied countries has been outlined in Annex 1.

Estimating the level of delay or development of RES in CEE as compared to the reference country, which is Germany, provides essential information on the competitiveness of these economies in the regulatory environment of the EU. At the same time, CEE countries rejecting the German model of energy transformation based on gas indicates that we are witnessing the rise of a new model of energy transformation.

The current study is based on the data of 2021 from before the Russian aggression on Ukraine. The duration of investment processes in the energy sector (apart from PV prosumers) does not allow yet to see the effects of geostrategic changes on time delay.

The delay observable between Poland and Germany in 2004–2021 was characterised by a steady growth which reached the level of 32 years in 2020, only to shrink to 27 years in 2021. Similar trends were recorded in other countries. While studying the presented method, it should be stressed that it does not show the real lag, but just the trend and direction of change, which clearly points out CEE countries have deteriorated their position versus Germany, when measured by the share of RES in general consumption. The situation in Baltic countries looks relatively most positive, and their 2021 time delay versus Germany in terms of the indicator studied amounted to: in Estonia – over 9 years, in Latvia – over 12 years and in Lithuania – over 13 years. The situation for the index studied is definitely the worst in Belarus and Ukraine (see Table 3). The position of these two countries may be systematically worsening, both due to the war in Ukraine and because of the financial resources which the EU is planning to spend on developing RES under the Multiannual Financial Framework (MFF) for the years 2021–2027, the National Recovery Plan (NRP) or Modernisation Fund (MF) for 2021–2030.

The conducted studies indicate significant diversification of CEE in terms of developing RES as well as a systematically worsening situation of countries in this region versus Germany (the established reference country) until 2020. Data for 2021 show that the situation of CEE countries has improved. It is not explicit that 2021 data represent a reversing trend, as the stability of public policies in the field of energy policy in CEE is rather low. Current key success factors are technological and organisational advantages as well as the social awareness of the importance of change.

Table 3. Delay of CEE countries in relation to Germany

Country / Year	Poland		Czech Republic		Hungary		Slovakia		Lithuania		Latvia		Belarus		Estonia		Croatia		Bulgaria		Romania		Slovenia		Ukraine	
	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t	$\tilde{t}$	t
2004	7.77	6.8	8.23	7.2	7.86	6.9	11.75	10.8	7.22	6.2	6.17	5.2	97.77	96.8	6.19	5.2	9.04	8.0	8.99	8.0	8.36	7.4	17.95	17.0	23.75	22.8
2005	9.03	7.0	9.71	7.7	9.83	7.8	13.72	11.7	8.02	6.0	6.98	5.0	115.46	113.5	6.90	4.9	9.92	7.9	10.09	8.1	9.29	7.3	21.49	19.5	27.29	25.3
2006	10.38	7.4	11.28	8.3	11.93	8.9	15.82	12.8	8.88	5.9	7.83	4.8	134.34	131.3	7.65	4.7	10.87	7.9	11.27	8.3	10.28	7.3	25.27	22.3	31.07	28.1
2007	13.66	9.7	15.11	11.1	17.03	13.0	20.92	16.9	10.97	7.0	9.92	5.9	180.30	176.3	9.49	5.5	13.16	9.2	14.14	10.1	12.70	8.7	34.46	30.5	40.26	36.3
2008	14.56	9.6	16.16	11.2	18.43	13.4	22.32	17.3	11.54	6.5	10.49	5.5	192.89	187.9	10.00	5.0	13.79	8.8	14.93	9.9	13.36	8.4	36.98	32.0	42.78	37.8
2009	16.05	10.0	17.89	11.9	20.74	14.7	24.63	18.6	12.48	6.5	11.44	5.4	213.66	207.7	10.83	4.8	14.83	8.8	16.23	10.2	14.46	8.5	41.13	35.1	46.93	40.9
2010	16.82	9.8	18.80	11.8	21.95	14.9	25.84	18.8	12.98	6.0	11.93	4.9	224.55	217.5	11.26	4.3	15.38	8.4	16.91	9.9	15.03	8.0	43.31	36.3	49.11	42.1
2011	21.69	13.7	24.48	16.5	29.52	21.5	33.41	25.4	16.08	8.1	15.03	7.0	292.72	284.7	13.99	6.0	18.79	10.8	21.17	13.2	18.62	10.6	56.94	48.9	62.74	54.7
2012	24.24	15.2	27.45	18.4	33.49	24.5	37.38	28.4	17.70	8.7	16.65	7.7	328.39	319.4	15.42	6.4	20.57	11.6	23.40	14.4	20.49	11.5	64.08	55.1	69.88	60.9
2013	24.95	15.0	28.28	18.3	34.59	24.6	38.48	28.5	18.15	8.2	17.11	7.1	338.34	328.3	15.81	5.8	21.07	11.1	24.02	14.0	21.02	11.0	66.07	56.1	71.87	61.9
2014	28.39	17.4	32.29	21.3	39.94	28.9	43.83	32.8	20.34	9.3	19.29	8.3	386.45	375.5	17.74	6.7	23.47	12.5	27.03	16.0	23.55	12.6	75.69	64.7	81.49	70.5
2015	32.95	21.0	37.61	25.6	47.03	35.0	50.92	38.9	23.24	11.2	22.20	10.2	450.31	438.3	20.29	8.3	26.67	14.7	31.02	19.0	26.91	14.9	88.46	76.5	94.26	82.3
2016	32.33	19.3	36.89	23.9	46.07	33.1	49.96	37.0	22.85	9.8	21.80	8.8	441.66	428.7	19.95	6.9	26.23	13.2	30.48	17.5	26.46	13.5	86.73	73.7	92.53	79.5
2017	36.89	22.9	42.20	28.2	53.15	39.2	57.04	43.0	25.75	11.7	24.70	10.7	505.39	491.4	22.50	8.5	29.42	15.4	34.46	20.5	29.81	15.8	99.48	85.5	105.28	91.3
2018	39.63	24.6	45.41	30.4	57.43	42.4	61.32	46.3	27.49	12.5	26.45	11.4	543.88	528.9	24.04	9.0	31.34	16.3	36.87	21.9	31.84	16.8	107.18	92.2	112.98	98.0
2019	43.79	27.8	50.25	34.3	63.89	47.9	67.78	51.8	30.14	14.1	29.09	13.1	602.01	586.0	26.36	10.4	34.25	18.3	40.50	24.5	34.90	18.9	118.80	102.8	124.60	108.6
2020	49.39	32.4	56.79	39.8	72.61	55.6	76.50	59.5	33.70	16.7	32.66	15.7	680.46	663.5	29.50	12.5	38.17	21.2	45.40	28.4	39.02	22.0	134.49	117.5	140.29	123.3
2021	45.41	27.4	52.14	34.1	66.41	48.4	70.30	52.3	31.17	13.2	30.12	12.1	624.68	606.7	27.27	9.3	35.38	17.4	41.92	23.9	36.09	18.1	123.34	105.3	129.14	111.1

Source: self-reported data.

Old-new mechanisms for supporting transformation

According to the data of 8 April 2022, the Recovery Fund is used by the following CEE countries, member states of the EU [Kucharczyk, 2022][3]:

- Bulgaria – 6.3 bn EUR – the plan was approved on 7 April 2022;
- Croatia – 818.41 m EUR in the form of grants;
- Czech Republic – 914.64 m EUR in the form of grants;
- Estonia – 126.01 m EUR in the form of grants;
- Latvia – 237.38 m EUR in the form of grants;
- Lithuania – 289.15 m EUR in the form of grants;
- Romania – 1.85 bn EUR in the form of grants and 1.94 bn EUR in the form of loans;
- Slovakia – 822.72 m EUR in the form of grants;
- Slovenia – 231 m EUR in the form of grants;
- Poland – on 1 June 2022 the European Commission approved the National Recovery and Resilience Plan (NRP) providing for 106.9 bn PLN in the form of grants and 51.6 bn PLN in the form of loans (which is 23 bn EUR in grants and 11.5 bn EUR in loans);

Hungary which sent its NRP to the European Commission in May 2021 is still waiting for approval – the plan has not been accepted yet.

The National Recovery Plan in each country is being widely discussed, particularly in terms of its effect on the economy, society or political issues.

Irrespective of the talks conducted in each country concerning the NRP, one should bear in mind the dates (the final time for using the NRP funds is 2026) when the funds may be available and the consequences of establishing deadlines. Changing value of currencies over time, access to installations or potential contractors are the factors which put the countries that start project implementation as first on the advantage. Moreover, it should be clearly stated that NRP goals and energy transformation, along with RES investments or energy efficiency, are recognised today as key purposes, yet many of such projects, due to a dragging time of their preparation and implementation, in practice may fail to come into existence. It should be also borne in mind that providing funds by the European Commission is conditional on Poland delivering the so called mile stones, being the requirements which, according to the EC, must be met prior to receiving financing from NRP.

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3 The support amount stands at 9–13% of the amount declared in the NRF. The remaining funds will be paid in tranches when countries prove they are implementing goals in line with the goals of the Recovery Fund. See more on: https://www.gov.pl/web/planodbudowy (accessed: 4.05.2022).

Impact of the pandemic, price shocks and war in Ukraine on the development of infrastructure

Concerns about the coronavirus pandemic

At the turn of 2019 and 2020 the world was swept by the COVID-19 pandemic. The scale of this threat was so huge that severe economic consequences started to be expected. The fear was fully justified as the pandemic affected both the demand and supply side of the economy. Consequences for the demand side were most of all felt in the service sectors, where sanitary restrictions partly or completely disrupted these sales processes which required direct contact with customers – the hardest hit were the catering, hospitality and passenger transport industries. Sanitary restrictions affected also other sectors, including industrial production, but to a lesser degree and in more diverse ways. There were disruptions on the supply side in supply chains, which led to cost derived inflation – it first affected semi-finished goods, particularly construction materials.

The reaction of some world countries to the exogenous shock of the pandemic was an easier fiscal and monetary policy on the supply side, geared towards sustaining economic activity, which managed to protect many of these economies from more grave macroeconomic consequences of the pandemic. A somewhat delayed side effect of these measures has been the monetary inflation – first occurring on the component markets, where supply chains had been crippled, and then in 2022 spilling also to consumer products.

Due to the above, the expectation that the pandemic would have some impact on the energy sector seemed justified, particularly in terms of the power transmission sub-sector, i.e. the electro-energetic power transmission grid as well as the transmission grids for crude oil and natural gas. As may be currently seen, these worries had not come true. When the pandemic seemed to be fading, particularly in terms of the economic repercussions, new perils became apparent – the Russian aggression on Ukraine took place, bringing about hostile acts against other countries.

Confirmed resilience of transmission grids to the effects of the pandemic

The available research into economic sectors shows their diversified immunity to the the pandemic-derived crisis[4]. The more a given sector or even company of the sector is digitally advanced, the less profound the exogenous shock caused by the pan-

[4] The latest research into these problems is worth recommending. [Bloom, Bunn, Mizen, Smietanka, Thwaites 2021; Russell, Stewart 2021; Ark, Vries, Erumban, 2021].

demic and the more robust and faster its economic recovery after the crisis. Some sectors responded flexibly to the new rules of operations by implementing new sanitary safety regulations and implementing remote work on a large scale.

It is widely known that power grid and infrastructure sectors are computerised practically in every country. Technical standards are similar everywhere, which is due to relatively uniform technical norms of the energy sector, as well as from international agreements. The degree of advancement of power grid technologies is very similar across all countries due to common boundary conditions for the functioning of electro-energetic technical equipment. This characteristic implies that the computerised and standardised energy sector can be one of these areas which are best equipped to accommodate the crisis circumstances of the pandemic, and in hindsight, the experience of the pandemic seems to fully confirm this reasoning.

Owing to the fact that the energy sector is of strategic significance, it is also strongly dependent on the condition of the entire economy[5]. In 2020 the demand for electric energy fell dramatically[6]. However, this slump was smaller than expected, thanks to which in 2021 the demand not only recovered, but also went into surplus. Decreased energy consumption in companies was compensated by higher use in households [Elavarasan i in., 2020]. Power grids, despite temporary problems, have emerged unaffected [PSE, 2021a; ENTSO-E, 2020b, 2020c; EPRI, 2020]. This means the incomes of energy operators may see merely slight falls, which should not present any particular challenge to efficient operations of the electric energy transmission sub-sector, a condition also aided by the supervision of the public regulator. Theoretically, though, lower incomes of the commercialised energy sector may result in reduced investments.

Therefore, the projected power grid investments could follow the line of least resistance and be partly postponed to indefinite future, because the old energy objects are able to meet the current limited demand for energy in the crisis environment. Simultaneously, reduced income of the society at large may diminish access to financing for the planned investments. Most opinions have it that the pandemic will cause delays but not an abandonment of the adopted and practised transformation policy. After a rapid slowdown, the activity will bounce back, which in the perspective of 2022 seems a fair judgement [IEA, 2022c]. It is paramount that countries have political

5 Long term consequences of this situation are highly uncertain and may produce lower investment activity in the sector [Congressional Research Service, 2020].

6 It was estimated that the demand for electric energy in 2020 was lower by 2% [IEA, 2020b], yet these data were later reviewed and stated as practically neutral decreases [IEA, 2022c]. In 2021 a global slump in demand reached 6%. Earlier in 2020 the demand in Europe fell by 4% [IEA, 2022c], which was provided for in the estimates of December 2020. A 4% increase in the demand for electric energy in 2021 levelled out the losses. Clearly, the share of RES kept growing in 2020 [IEA, 2020c, 2020d], but this growth rate slowed down in 2021and was below the above mentioned demand growth rate [IEA, 2022c].

determination in following the adopted strategies [e.g. IEA, 2020a, 2020e], which will help them continue suitable activities – many countries decided already at the outset to take a preventive measure and extend deadlines of placing in service some implemented projects [e.g. IEA, 2020f]. All stakeholders of the process (both the EU institutions, European energy organisations and other entities as well as particular power grid operators etc.) explicitly declare that investments will be carried on and energy transformation will not be postponed [e.g. PSE 2021b]. In order to cause cracks to this network of firm decisions in the energy sector, including the energy transformation, it would be necessary to stay exposed to the crisis for many years, which from the perspective of 2022 seems unrealistic. The gas and oil transmission power grids were even less affected by the pandemic, and just like with electro-energetic grids the adopted projects had not been abandoned. Possible delays are nothing uncommon, they are very frequent with long term investments where timetables are full of work stoppages and lags [Księżopolski, Maśloch, Kotlewski, 2021].

Planning and investment activity in the transmission sectors and future changes

According to TYNDP 2020 [ENTSO-E, 2021b, p. 64–65] there have been over 70 projects of expanding electro-energetic transmission grids (interconnectors) recently planned and implemented, 13 of which are in the CEE region. Currently, according to TYNDP 2022 [ENTSO-E, 2022b], there are about 140 such projects planned and implemented, about 25 of them completely new ventures (7 in CEE). These data indicate a rising planning and investment activity in the expansion of electro-energy grids. Turbulence on the markets has not affected the completion of projects of electro-energetic transmission grid expansion. On the contrary, expectations created by the newly emerging needs related to the green transformation of the energy sector stimulate the launch of more projects in the field of electro-energetic grids – this trend will only be enhanced by the new threats to energy market supplies resulting from the hybrid war and the "hot" war conducted by Russia. It should be borne in mind, though, that the sources of data for 2022 used in this study were working drafts published by ENTSO-E, thus they are not fully compatible with final documents of 2020 and 2021. Projects mentioned in all of these documents (particularly those of 2022) may be soon reviewed (e.g. not approved for implementation) as a result of their cost-benefit analysis – this becomes even more probable when projects competing on their functionality overlap (e.g. closely located transmission lines serving the same areas), and their simultaneous implementation produces lower net socio-economic benefits than the sum of their individual gains [ENTSO-E, 2021a, s. 7; 2022a]. The above data should be therefore treated as indicative, as not all projects provided for in the Ten-Year Network Development Plan 2020 will be finally implemented [ENTSO-E, 2020a].

Despite the data presented above not being fully accurate, the projects of expanding electro-energetic and transmission grids should be treated as highly probable in the light of conclusions from the *Development plan for meeting the current and future demand for electric energy in 2021–2030* [PSE, 2020]. In the new PSE (Polish Electro-Energetic Grids) document for 2022 the issue was also stated like this: “Structural environment changes resulting from increasing decentralisation of the manufacturing sector, rise of renewable energy sources and continuous development of technologies in these areas, prospects of developing offshore wind power, nuclear energy programmes, a growing use of electric energy in the transport and heating sectors, advancing digitalisation and reduction of some conventional manufacturing resources reveal further challenges which need to be addressed by future grid infrastructure development plans”. This approach is confirmed in EU documents like UE [ENTSO-E, 2021c], in which major savings in the sub-sector of electric energy production and the entire electro-energetic system are forecast if the electro-energetic grid is expanded. Unless the current war in Ukraine escalates and spills over to other countries which are not directly involved, there are no reasons to believe the development of the electro-energetic transmission grid should be halted. Even more so, because abandoning the transmission grid development activities may make it completely incompatible with the current needs already in 2025 [ENTSO-E, 2021b, p. 12].

Russian aggression may accelerate the synchronisation of the electro-energetic grid in the Baltic countries (in Lithuania, Latvia and Estonia) with the continental west-European electro-energetic grid – Continental Europe Synchronous Area (CESA, former UCTE). Europe is divided into five synchronised electro-energetic systems. Two major areas are the previously mentioned CESA, comprising all countries of the continental Europe, and the IPS/UPS system inherited from the former Soviet Union, serving its historical countries, including among others Ukraine, Belarus and the Baltic countries. Three smaller areas are: the NORDEL system comprising three Scandinavian countries (Norway, Sweden and Finland), UKTSOA system operating in Great Britain and ATSOI serving Ireland and North Ireland. These three areas are not synchronous with the continental CESA system and with each other for technological reasons. Transmission cables of alternating current laid on the sea bottom are highly inefficient in electric energy transmission (works are pending on solving this problem), thus direct current transmission cables are used, which does not require mutual synchronisation of electro-energetic grids in the areas separated by the sea. Apart from the conception which has never been implemented of creating a great Euro-Asian electro-energetic grid connecting IPS/UPS system with

CESA (or even with the five aforementioned systems) that will most certainly be postponed due to the Russian aggression on Ukraine, it is planned to disconnect the electro-energetic grid of the Baltic countries from the IPS/UPS system and connect them to the west-European continental CESA system – the process to be completed in 2025. In principle, no risk of cutting off Baltic countries from electric energy supplies due to technological issues should be expected (it is prevented by the specifics of their energy production as well as consumption), yet during escalating military conflicts anything is possible – Russia recently disconnecting Finland from its electric energy supplies serves a warning example. These planned solutions can be also justified by the pursuit of eliminating electric energy quality problems – in certain circumstances CESA system may prove more reliable. Russian aggression on Ukraine may therefore accelerate detaching Baltic countries from the electro-energetic system inherited from the former Soviet Union and their inclusion in the CESA system [Brown, Claeys, Vangenechten, Lovisolo, 2022].

On 16 March this year Ukraine and Moldova have been synchronised with CESA in an emergency mode, the process which had been planned to end in 2023, due to the war took three weeks to complete. In April exports of electric energy from Ukraine to Poland were resumed via the line connecting Dobrotvir and Zamość[7].

In the case of gas transmission grids the situation seems even more obvious. Gas interconnectors allow for a fuller exploitation of LNG terminal infrastructure and backhaul gas pipelines of different countries. Finally, independent bilateral relations between importers and exporters should be replaced with a universally accessible transmission grid serving all participants of the pan-European system. This is a way for individual countries to reduce their sensitivity to halting supplies (also thanks to making emergency gas reserves internationally available). At the same time, supplies may be frozen due to sanctions imposed on Russia or retaliatory measures applied by the Russia itself as a producer, which makes the aforementioned steps highly necessary, even after the military conflict subsides. Another important plan involves increasing the number and significance of transmission pipelines of hydrogen [ENTSO-G, 2022], which, apart from its standard use in the energy sector, can be also successfully employed in metallurgy, even though the pipeline transport of hydrogen is much more expensive per one unit of transmitted energy than that of natural gas, its clear environmental and process advantages and high efficiency for metallurgy, higher than that of coal, in the situation of short distance transportation may prevail over potential shortcomings, particularly in comparison to natural gas which is usually supplied over long distances. Hydrogen enables short term storage

7 It is a classical radial connection with an island and works in a synchronous mode.

of energy produced by the fluctuating-level sources, such as wind and solar power plants, and can be used in heating, next to the already discussed environmentally-friendly and efficient metallurgy production.

Expansion of the infrastructure refers also to the oil transmission networks (oil terminals and pipelines), the situation here is easier in terms of supply diversification, as the European and global systems have bigger buffers. Substitution of crude oil by other sources and energy media is more difficult but inevitably happening. Most certainly road transport will be electrified in the future, which is more probable than replacing other resources with very costly hydrogen, but this does not provide any solution to the current threat of the hybrid and "hot" war fought by Russia. Bio-fuels have already experienced economic and quantity limitations, so they cannot provide any relevant answer to present challenges. Thus, although in the long term future it is expected that oil-based fuels will be replaced with other energy media, currently the only response may be diversifying supplies and taking up efficiency actions (speed limits etc.). In the near future the trend will be encouraged by further expansion of the infrastructure used for imports and storage of this resource. It is of particular importance to countries whose infrastructure has been until recently oriented solely towards imports of oil from Russia. For example in Poland the second leg of the Pomeranian crude oil pipeline is under construction (along the existing leg) between Miszewko Strzałkowskie – Gdańsk. It will be a transmission oil pipeline allowing for a two-way flow (so called reverse flow) with a transmission capacity of 25 m tonnes of crude oil annually. Also the storage capacity is being expanded [PERN, 2022].

In the light of the above, the answer to the question about whether price shocks and the hybrid war have led to halting the development of energy infrastructure, particularly that of electric energy, natural gas and crude oil, seems more than obvious. Generally speaking, no halts or delays may be observed. Quite to the contrary, in transmission sectors a significant expansion of investment activity can be seen, it has not been hindered by the COVID-19 pandemic, and the perils caused by the hybrid war and the "hot" military conflict on the territory of Ukraine seem to drive more intensive development actions.

Activity of selected companies in the energy sector in the time of war between Russia and Ukraine

A price change analysis presented in the second part of this study shows that as a result of gas price hikes, companies in the energy sector with production fleets based on coal have gained a competitive advantage over other entities which followed EU recommendations and grew their fleets using gas.

Certainly, the most important event in the region is tightening of cooperation between PKN Orlen and Lotos resulting in, meeting the requirements of the European Commission, a petrol station swap deal with the Hungarian MOL and signing an agreement with Saudi Aramco for the acquisition of 20% of shares in Lotos refinery. The process is under way despite the final stage of the pandemic and the Russian aggression on Ukraine. It is not possible to assess the acquisition of Lotos by PKN Orlen from the point of view of energy and economic security as there is no access to contract provisions between PKN Orlen, MOL and Saudi Aramco.

Prospects of the petrochemical sector development in CEE look fair because the infrastructure of the countries in the region is ready to source crude oil from other than Russia suppliers. We could see some example in 2019. In January 2022, shortly before the war broke out, Urals-Brent differential had reached its historical high of 30 USD per barrel, which means that in medium term, until sanctions are imposed, extraordinary gains can be expected. The war in Ukraine causes higher demand for fuels, both on the side of the military and civil logistics. The exposure of PKN Orlen, Lotos and MOL is varied. The cooperation policy of Hungary with Russia run by Wiktor Orban has caused MOL's direct exposure to the Russian market through BaiTex company which has oil exploration licenses for Baitugan and Yerikinsk. Daily production there amounts to 4 m barrels, and the 2P reserves held by the company reach 27 m barrels, which accounts for 7% of MOL's potential. On the other hand, Lotos and PKN Orlen have no assets in Russia. The total exposure of refineries from CEE to the Russian crude oil amounts to 60%. Regional leaders in this respect are MOL in Slovakia (95%) and PKN Orlen in Możejki (66%). Polish government's policy of reducing imports of Russian resources caused PKN Orlen to systematically shrink the proportion of crude oil sourced from this country in 2019–2021 (from 76% to 66%). It should be noted that the terminal in Butinge has the handling capacity of about 14 m tonnes of crude oil, and Możejki refinery's demand accounts only for 10 m tonnes of crude oil annually.

Upon signing a deal with Saudi Aramco, PKN Orlen declared that 50% of crude oil processed after acquiring Lotos will be sourced from that supplier, so it will not be Russian oil. Currently Orlen has two long term contracts with Rosnieft, under which 3.6 m tonnes of crude oil are supplied to Poland and 5 m tonnes to the Czech Republic. They satisfy 29% of demand for crude oil.

Investment processes aimed at building wind farms on the Baltic Sea, both in Poland where the works are very advanced, as well as in other Baltic countries like Lithuania, Latvia and Estonia, are under way. It will significantly increase the share of RES in Poland's energy mix by 2030 through the installation of at least 5.9 GW of power in the first stage. These investments engage companies controlled by the State Treasury such as PGE and PKN Orlen, private capital entities, stock-listed companies including Polenergia, and foreign companies – Equinor, RWE, Ocean Winds, Orsted, Northland Power. Price effects of the Russian aggression on Ukraine cause vital consequences for the projects being implemented in the first stage of Offshore Wind Power development, as they have to account for the rising prices of materials and labour in their CAPEX and OPEX stages. Although companies involved in this stage received a rescue mechanism in the form of a contract for difference in the inflation rate, it may adversely affect the execution dates of the project. Also geostrategic conditions of placing these investments on the Baltic Sea, close to the biggest non-freezing Russian navy base, increase the risk of hybrid threats occurring during the installation. It poses a challenge to companies making these energy investments in CEE, particularly in the front-line countries bordering Russia and/or Belarus.

Summary

1. Russia's preparations for the aggression on Ukraine had disrupted the ways in which the EU energy market operated and its development model to date. Strong impulsive price swings triggered higher inflation, which made CEE countries take extraordinary measures, i.e. slashing energy taxation scale. The war and actions preceding the conflict once more have made it very clear that the energy market is ruled by the principles of economics as well as political gaming. The present geostrategic and market circumstances encourage interventionist policies of countries, rendering full-blown consequences for all market players.
2. The pandemic, Russia's aggression on Ukraine, as well as the dependence of CEE and the entire EU on crude oil and natural gas imports make RES a preferred way of meeting energy demand. The nature of nuclear energy production makes it also an increasingly attractive source of energy.
3. A vital challenge to CEE and the entire EU is to determine ways of balancing out the electro-energetic system with an increasing share of RES. Underdeveloped electro-energetic grid remains an important barrier to raising RES share, but expanding interconnectors may be one of the ways of balancing electro-energetic systems. Development of RES seems a preferred path of developing energy production in CEE and is dependent on the prices of energy obtained from traditional sources (the higher and less stable the prices of resources, the faster the development of RES), and on the technological progress in energy storage, use of hydrogen and biogas, as well as on overcoming infrastructural issues in gas imports across the EU.
4. CEE countries, particularly Poland, having carried out accurate risk assessments and drawn conclusions as to the development of gas and oil transport infrastructures,

have achieved a strategic competitive advantage over countries of the "old" EU, particularly Germany. This strategic advantage raises the importance of Poland in CEE as the future guarantor of energy security in terms of natural gas and crude oil supplies in the region.

5. Lack of decisions on imposing economic sanctions in the form of import bans on gas from Russia to the entire EU sparks insecurity in the energy sector and lowers the propensity for implementing transformational changes before winter 2022/2023, such as extending the life of nuclear and coal power plants, replacing gas with other energy sources or taking measures on the demand side. Import sanctions on crude oil and petroleum products introduced in June 2022 have been delayed by 6–8 months, some exemptions for CEE countries such as Hungary, Croatia and Bulgaria have also been adopted, which has undermined the unity of the Euro-Atlantic area. It has an adverse effect both on the already limited efficiency of sanctions and on the next packages of the discussed solutions.
6. Due to the Russian aggression on Ukraine the danger of hybrid war instruments being used to hit the energy sector has increased considerably, in particular against the Baltic countries, Poland and Romania.
7. Time delay analysis demonstrates some variation in the pace of RES development among CEE countries. Detailed findings point out to the possibility of increasing RES dynamics and that this trend is to be expected in the future, also advanced work in Poland and the Baltic countries on offshore wind power indicates the parameters will change dynamically after 2027. Due to very high volatility of energy policies in CEE countries, it is impossible to decide whether decreasing time delay recorded in 2021 signifies a sustainable trend change.
8. Although not all planned electro-energetic interconnectors can be quickly launched, continuing and accelerating the process of electro-energetic grid integration remains a "partial solution" to disruption problems on the supply side as it allows for a fuller use of the existing electric energy supply objects and better cooperation of various production technologies in electro-energetic grids, leading to increased shares of currently more desirable sources, that is own resources, including renewable sources.

ANNEX

Attachment 1 Characteristics of the time delay method

Methods of analysing spatio-temporal analogies turn out highly useful in studying the competitiveness of countries, regions and their economies. Their essence is in transferring certain regularities of phenomena changing in time from some objects to others [Duncan, Gorr, Szczypula, 2001]. The methods are particularly useful and widely applied in forecasting and analysing the energy sector development, specifically in the field of renewable energy [Księżopolski, Maśloch, 2001].

The use of spatio-temporal analogy methods requires the application of time series for the forecast variable and the forecast object, as well as for similar objects treated as benchmark objects [Grabiński, 1986; Szozda, 2010].

In this case " (...) benchmark formulas are various distances of particular objects from the benchmark object which in empirical studies is known as the bottom (anti-benchmark method) or top growth pole (benchmark method). For the benchmark formula, the comparison of a given object to the benchmark object goes down to calculating a particular distance measure" [Czyżycki, 2012, pp. 18–19].

In order to conduct an analysis using the spatio-temporal analogy method the authors recommend a nine-stage research process which involves:

1) selecting countries to be studied (following the adopted assumptions, subjects of the analysis are countries of the CEE region: Belarus, the Czech Republic, Croatia, Slovakia, Slovenia, Poland, Lithuania, Latvia, Estonia, Bulgaria, Romania and Hungary);
2) selecting the method – for the purpose of the study the time-delay method proposed by Grabiński was chosen [1998, pp. 200–234];
3) selecting a benchmark object (country) – the benchmark (reference) country chosen was Germany as a leader of the energy transformation and renewable energy development in Europe;
4) selecting and studying statistical data on the energy generated from RES and the primary energy consumption, then bringing these data down to comparable units (TWh) (Tables 4–6);
5) processing data from point 4 for the countries mentioned in point 1 and for Germany as a reference country and generating a RES share ratio in the consumption of the final energy;
6) using the RES share ratio in the consumption of the final energy in a method allowing to calculate the time delay shift;

7) analysing study findings using the time delay shift method;
8) searching factors which can explain the study findings;
9) formulating final study conclusions.

The selected method specifies individual time delays between the forecast object Y_0 and the reference object Y_0. The study uses "ironed out" variable values Y_0 only for the forecast object Y_0. There are a few stages involved in the process.

First, based on the variable behaviour Y_0 trend function parameters are estimated f_0. A Classical Least Squares Method may be used for that purpose. The most frequently applied tools to describe development trends are the following functions: linear function, power function, exponential function, second degree polynominal and the logistic function. While describing the trend, it is also recommended, if practicable, to use non-statistical information, on the regularities observed in the development of a given phenomenon. Taking the above into account, this study uses a linear function to study the case in question.

When using a linear function approximation to determine time delays the following formulae may be applied [Grabiński, 1998, p. 209]:

$$Y_t^0 = a_0 + b_0 t + e_t;\ \text{parameter: } \tilde{t}_t = \frac{y_t^1 - a_0}{b_0}$$

The value of an individual time delay between objects Y_0 i Y_1 is established based on the formula:

$$d_t = \tilde{t}_t - t,$$

where $t = 1, \ldots, n$.

When making a variable prediction Y_0 only the variable information is used Y_1, for which $d_t > 0$.

Having estimated linear parameters with the Least Squares Method, the following values of the trend function were obtained.

For the reference country:

- For Germany: $\widehat{t_{DE}} = 0.0034t + 0.0021$, correlation coefficient $R^2_{DE} = 0.9782$.

For CEE countries:

- For Bulgaria: $\widehat{t_{BG}} = 0.0016t - 0.0051$, correlation coefficient $R^2_{BG} = 0.9384$;
- For Croatia: $\widehat{t_{HR}} = 0.0020t - 0.0088$, correlation coefficient $R^2_{HR} = 0.8780$;
- For the Czech Republic: $\widehat{t_{CZ}} = 0.0012t - 0.0006$ correlation coefficient $R^2_{CZ} = 0.9196$;
- For Estonia: $\widehat{t_{EE}} = 0.0025t - 0.0062$. correlation coefficient $R^2_{EE} = 0.8882$;
- For Hungary: $\widehat{t_{HU}} = 0.0009t + 0.0022$. correlation coefficient $R^2_{HU} = 0.8670$;
- For Latvia: $\widehat{t_{LV}} = 0.0017t - 0.0043$. correlation coefficient $R^2_{LV} = 0.8838$;
- For Lithuania: $\widehat{t_{LT}} = 0.0022t - 0.0066$. correlation coefficient $R^2_{LT} = 0.9544$;
- For Poland: $\widehat{t_{PL}} = 0.0014t - 0.0016$. correlation coefficient $R^2_{PL} = 0.9549$;

- For Romania: $\widehat{t_{RO}} = 0.0019t - 0.0066$. correlation coefficient $R^2_{RO} = 0.8603$;
- For Slovakia: $\widehat{t_{SK}} = 0.0009t - 0.0013$. correlation coefficient $R^2_{SK} = 0.9470$;
- For Slovenia: $\widehat{t_{SLO}} = 0{,}0005t + 0.0003$. correlation coefficient $R^2_{SLO} = 0.9158$;
- For Ukraine: $\widehat{t_{UA}} = 0.0005t - 0.0026$. correlation coefficient $R^2_{UA} = 0.5879$;
- For Belarus: $\widehat{t_{BY}} = 0.0001t - 0.0005$. correlation coefficient $R^2_{BY} = 0.7718$.

Correlation coefficients indicate that the studied variables for all countries, except Belarus and Ukraine, are very strongly correlated. Thus, correlation coefficients calculated for all functions confirm very high compatibility of matching the function to empirical data, which allows to continue the study. The remainders *ei* relating to subsequent observations are calculated using the formula: $e\mathrm{i} = Y\mathrm{i} - i$.

Table 4. Primary energy consumption (TWh)

Country / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bulgaria	219	239	244	236	231	203	211	225	214	197	211	225	211	217	217	211	194	217
Croatia	111	108	108	108	108	106	106	94	89	97	97	92	94	94	97	94	92	100
Czech Republic	528	519	531	525	514	492	514	503	500	492	481	469	464	486	483	478	442	467
Estonia	64	64	64	75	67	58	72	72	72	78	75	69	69	78	78	64	58	67
Hungary	288	307	303	300	297	273	278	269	250	239	239	249	256	269	272	275	269	283
Latvia	44	47	44	47	47	44	50	44	47	44	42	42	44	50	44	44	42	42
Lithuania	103	94	89	97	97	89	67	69	69	64	61	64	64	69	69	69	69	69
Poland	1040	1063	1116	1111	1131	1089	1161	1167	1133	1136	1092	1106	1153	1199	1213	1176	1115	1233
Romania	458	458	467	450	1131	394	399	409	393	367	380	382	383	389	396	387	370	389
Slovakia	214	225	215	203	211	190	192	205	197	189	194	181	183	184	194	191	185	181
Slovenia	86	86	86	86	94	86	86	83	81	81	83	75	81	81	83	81	77	75
Ukraine	1586	1605	1625	1618	1562	1331	1427	1475	1443	1370	1208	1003	1050	975	1012	958	918	926
Belarus	286	283	303	295	299	283	306	301	325	295	295	267	273	278	307	309	287	307
Germany	4011	3964	4061	3894	3935	3692	3847	3710	3762	3868	3708	3778	3840	3890	3793	3695	3432	3511

Source: self-reported data based on BP [2022].

Table 5. Renewable power generation (TWh)

Country / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bulgaria	0.00	0.01	0.02	0.05	0.14	0.25	0.73	1.02	2.10	2.85	2.78	3.11	3.16	3.30	4.23	4.58	4.66	4.62
Croatia	0.01	0.02	0.03	0.04	0.06	0.08	0.17	0.26	0.43	0.65	0.93	1.12	1.51	1.81	2.08	2.52	2.89	3.35
Czech Republic	0.59	0.67	0.96	1.31	1.71	2.24	3.10	5.22	5.95	6.54	7.26	7.63	7.39	7.75	7.78	8.02	8.02	8.01
Estonia	0.04	0.09	0.11	0.13	0.17	0.51	1.02	1.15	1.44	1.20	1.35	1.50	1.49	1.78	1.93	2.06	2.75	3.11
Hungary	0.73	1.67	1.31	1.67	2.14	2.67	2.83	2.49	2.43	2.57	2.85	3.00	3.00	3.26	3.55	4.47	5.29	6.66
Latvia	0.09	0.09	0.09	0.10	0.10	0.10	0.12	0.19	0.40	0.62	0.77	0.92	0.95	1.08	1.07	1.08	1.05	0.97
Lithuania	0.01	0.01	0.04	0.16	0.20	0.26	0.37	0.63	0.76	1.00	1.11	1.33	1.64	1.94	1.77	2.12	2.27	2.04
Poland	0.99	1.65	2.25	3.08	4.45	6.30	7.97	10.81	14.84	14.63	17.66	20.65	20.67	21.56	19.65	23.50	25.30	27.77
Romania	0.00	0.01	0.01	0.04	0.03	0.02	0.42	1.59	2.86	5.19	6.52	9.57	8.94	9.79	8.53	9.06	9.22	8.99
Slovakia	0.03	0.04	0.40	0.48	0.52	0.54	0.69	1.22	1.37	1.51	2.02	2.17	2.27	2.21	2.22	2.29	2.34	2.72
Slovenia	0.12	0.11	0.10	0.10	0.29	0.20	0.23	0.32	0.43	0.48	0.52	0.55	0.56	0.58	0.53	0.57	0.65	0.61
Ukraine	0.03	0.08	0.15	0.33	0.31	0.18	0.24	0.25	0.76	1.31	1.69	1.71	1.58	1.92	2.60	5.36	9.39	11.01
Belarus	0.00	0.00	0.00	0.02	0.03	0.06	0.09	0.10	0.10	0.09	0.09	0.14	0.19	0.29	0.33	0.46	0.62	0.74
Germany	37.2	43.8	52.5	68.3	73.9	77.0	84.5	106.8	121.7	129.0	141.4	168.3	167.7	194.7	204.4	220.6	231.8	217.6

Source: self-reported data based on BP [2022].

Table 6. Renewable power generation – primary energy consumption (TWh)

Country / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bulgaria	0.0000	0.0000	0.0001	0.0002	0.0006	0.0012	0.0035	0.0045	0.0098	0.0144	0.0132	0.0138	0.0150	0.0152	0.0195	0.0217	0.0240	0.0213
Croatia	0.0001	0.0002	0.0003	0.0004	0.0006	0.0007	0.0016	0.0027	0.0048	0.0067	0.0096	0.0122	0.0160	0.0191	0.0214	0.0267	0.0315	0.0335
Czech Republic	0.0011	0.0013	0.0018	0.0025	0.0033	0.0046	0.0060	0.0104	0.0119	0.0133	0.0151	0.0163	0.0159	0.0159	0.0161	0.0168	0.0182	0.0171
Estonia	0.0006	0.0014	0.0018	0.0017	0.0026	0.0087	0.0141	0.0159	0.0199	0.0154	0.0180	0.0216	0.0214	0.0228	0.0247	0.0322	0.0474	0.0464
Hungary	0.0025	0.0054	0.0043	0.0056	0.0072	0.0098	0.0102	0.0092	0.0097	0.0108	0.0119	0.0120	0.0117	0.0121	0.0130	0.0163	0.0197	0.0235
Latvia	0.0020	0.0019	0.0020	0.0020	0.0022	0.0022	0.0023	0.0043	0.0084	0.0140	0.0183	0.0220	0.0215	0.0216	0.0240	0.0244	0.0249	0.0230
Lithuania	0.0001	0.0001	0.0004	0.0016	0.0021	0.0029	0.0056	0.0092	0.0110	0.0157	0.0182	0.0208	0.0257	0.0280	0.0256	0.0306	0.0328	0.0295
Poland	0.0010	0.0015	0.0020	0.0028	0.0039	0.0058	0.0069	0.0093	0.0131	0.0129	0.0162	0.0187	0.0179	0.0180	0.0162	0.0200	0.0227	0.0225
Romania	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0011	0.0039	0.0073	0.0142	0.0171	0.0250	0.0234	0.0252	0.0215	0.0234	0.0249	0.0231
Slovakia	0.0001	0.0002	0.0019	0.0024	0.0025	0.0029	0.0036	0.0060	0.0070	0.0080	0.0104	0.0120	0.0124	0.0120	0.0114	0.0120	0.0127	0.0150
Slovenia	0.0014	0.0013	0.0011	0.0012	0.0031	0.0023	0.0027	0.0038	0.0053	0.0060	0.0063	0.0073	0.0069	0.0072	0.0064	0.0070	0.0084	0.0081
Ukraine	0.0000	0.0000	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002	0.0005	0.0010	0.0014	0.0017	0.0015	0.0020	0.0026	0.0056	0.0102	0.0119
Belarus	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0005	0.0007	0.0011	0.0011	0.0015	0.0022	0.0024
Germany	0.0093	0.0110	0.0129	0.0175	0.0188	0.0209	0.0220	0.0288	0.0323	0.0333	0.0381	0.0445	0.0437	0.0500	0.0539	0.0597	0.0675	0.0620

Source: self-reported data based on BP [2022].

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INNOVATIVENESS AND COMPETITIVENESS OF THE HEALTH AND PHARMACEUTICAL SECTOR

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Abstract

In the face of civilisation challenges, also known as Grand Challenges, such as population aging and the emergence of new diseases like the COVID-19, one of the important factors of the socioeconomic development is the innovativeness and competitiveness of the healthcare and pharmaceutical sector. The chapter aims to compare the level of innovation and competitiveness of the European Union's health care and pharmaceutical industries, particularly in Poland, to those of the United States and China. The research is an empirical examination of three interconnected economic levels: macro, meso, and micro.

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The aim of the study is to assess the level of innovativeness and competitiveness of the healthcare sector and pharmaceutical industry in the European Union (EU), including Poland, using an international contrastive perspective of two major world economies – the United States and China.

Poland and other countries of the region must face up to the global competition and focus on innovativeness. It is of particular importance in the present moment, when the health protection of citizens and, consequently, innovative solutions in healthcare become key challenges for the competitiveness of all world economies.

The study has employed empirical analysis conducted at three intertwined levels:

- macroeconomic: the analysis of the innovativeness and competitiveness levels of EU economies (particularly in terms of the healthcare sector and the pharmaceutical industry), including Poland, as compared against the United States and China;
- mesoeconomic: the analysis of the healthcare sector and the pharmaceutical industry of EU, including Poland, as compared against the United States and China;
- microeconomic: the analysis of innovativeness and competitiveness of enterprises in the Polish pharmaceutical industry as compared against other EU countries.

Analysis of innovativeness and competitiveness of European Union economies, including Poland, as compared against the Unites States and China

Technological advancement has always been the domain of developed economies, such as the United States and Western Europe. However, in the 21st century we have seen a gradually increasing innovation capacity of developing countries and a shift of advanced and medium high technologies to emerging markets, mostly to China [Weresa, Kowalski, Rybacki, 2022]. Significantly higher outlays on innovation explicitly make China a country of innovation research [Wen, Yang, Feng, Dong, Chang, 2018]. In recent years innovation has become also one of the key goals of Poland's economic policy, which is now aimed at raising competitiveness and innovativeness of the economy, additionally driven by EU financing. Consequently, a question arises about the dynamics of the innovation gap between China, Poland and innovation leaders of the recent years. The conducted study concerns two key innovativeness aspects: the innovation ability and innovation position of a country.

Innovation ability is a spending-oriented concept, reflecting a given economy's potential to create and commercialise new ideas.

Innovation position, on the other hand, is an achievement-oriented concept, focusing on the effects of innovation activity. Indicators included in sub-indices related to both of the categories measured at the economy level have been set out in Table 1.

Table 1. Indicators used to measure innovation ability (spending sub-index) and innovation position (output sub-index) of the economy

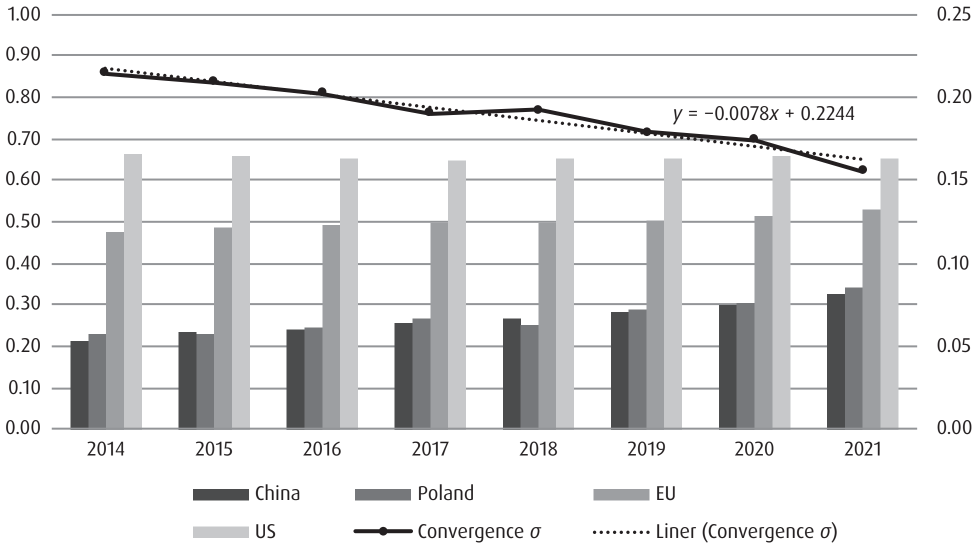
Innovation ability (spending sub-index)	Innovation position (output sub-index)
People aged 25–64 with university degrees	PCT Patent applications (per one billion GDP; PPS)
International scientific publications (per one million citizens)	Trade mark applications per one billion GDP (in PPS)
Scientific publications among 10% of the world most cited papers as a proportion of all publications in a given country	Industrial design applications (per one billion GDP; PPS)
Outlays on R&D works in the public sector (% GDP)	Exports of medium and high technology products as a proportion of total exports of products
Direct government financing and fiscal support to R&D activity of enterprises (% GDP)	Exports of knowledge services as a proportion of total exports of services
Outlays on R&D work in the business sector (% GDP)	Emissions of small solid particles (particle pollution) in industrial production (PM2.5)
Public-private co-publications (per one million citizens)	Development of environment protection technologies, proportion of all technologies

Source: self-reported data based on the methodology of the European Innovation Scoreboard 2021.

The average of standardised results in all indicated categories determines the value of subsequent input sub-indices, as shown in Figure 1. Additionally, convergence σ is analysed to check whether lower innovation potential economies are catching up with innovation leaders. Convergence σ is measured by a standard deviation and is observed when the studied variable difference between countries is shrinking over time.

The conducted analysis indicates significantly higher sub-indices of spending in US and EU as compared to China and Poland. In a dynamic approach we can see a convergence process between these four economies, represented by a declining trend line of the standard deviation. In the last decades, a particularly rapid increase in the innovation ability and performance could be noted in China. As mentioned by Kowalski [2021], the key to this country's development success is bridging the technological gap by importing modern technologies (this is being achieved by foreign direct investments concentrated mostly in eastern provinces and the technological transfers connected to them) and enhancing internal abilities to tap into them and refine them (by relevant education, technology and innovation policies, investments in research and development as well as creating regional innovation clusters).

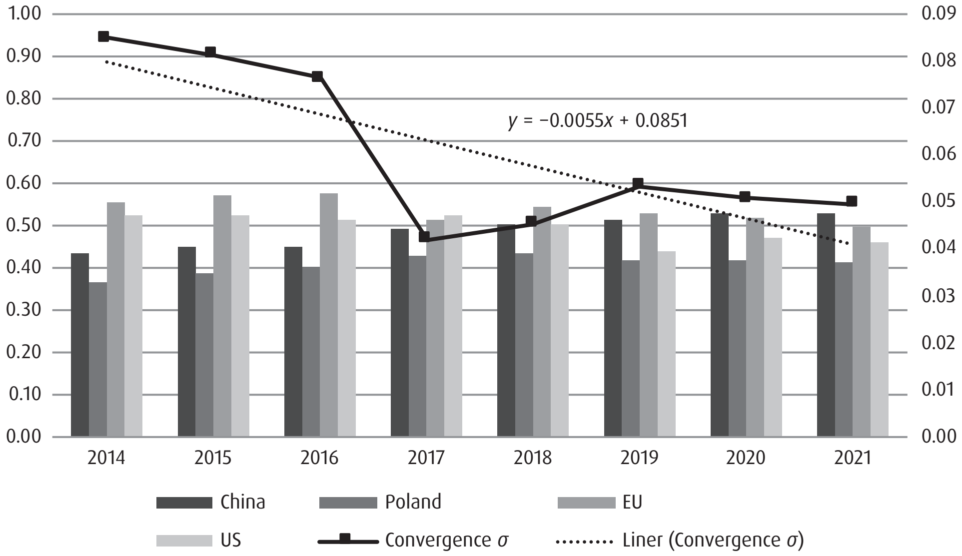
Figure 1. Sub-index values of spending and convergence σ determining the innovation ability of China, Poland, EU and US in 2014–2021



Source: self-reported databased on the data from European Innovation Scoreboard 2021.

A factor of outstanding importance to developing the pharmaceutical industry in China and receiving relevant technology transfers has been foreign direct investment (FDI). Pharmaceutical industry was one of the first sectors to open up to foreign investors. FDI has been flowing into China since 1980 when the first Chinese joint venture company with foreign capital was set up. Ever since then, China has been attracting vast numbers of foreign direct investments both as a result of spontaneous market dynamics and preferential policies at a regional level. Yet, there are considerable differences in FDI location between particular territories on the Chinese market [Li, Angelino, Yin, Spigarelli, 2017]. Nevertheless, foreign investments and advanced technologies drive modernisation and expansion of domestic pharmaceutical companies in China. Modern production lines and production technologies, as well as state-of-the-art skills and management strategies are transferred there, boosting the exchange of information and training. The value of output sub-indices measuring innovation position has been presented in Figure 2.

Figure 2. Values of output sub-indices and convergence σ determining the innovation position of China, Poland, EU and US in 2014–2021



Source: self-reported data based on the data from European Innovation Scoreboard 2021.

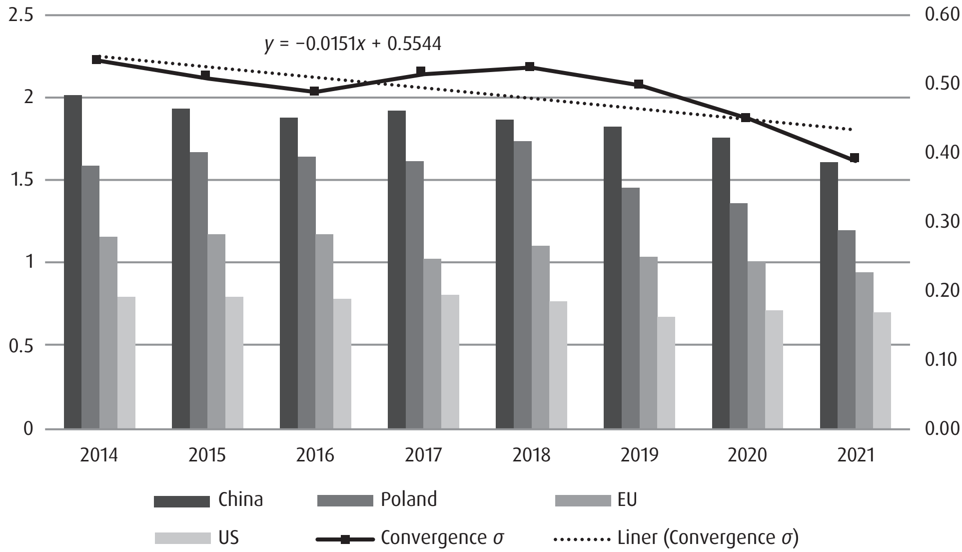
The analysis of output sub-indices proves there occurs a rapid convergence of innovation positions between the studied countries. China is the highest-scoring country in this respect. One of the potential reasons for this situation is the fact that the Chinese economy is heavily dependent on external sources of innovation and its innovation processes are driven by international technology transfers, specifically in technologically advanced industries, such as the pharmaceutical industry.

A more in-depth analysis of the innovation abilities and positions of economies is provided by studying relations between those elements, which allows to assess the efficiency of the innovation system. In the report Global Innovation Index 2018 [Dutta, Lanvin, Wunsch-Vincent, 2018] a new metric was proposed called an innovation efficiency ratio which is calculated as a relation of the output sub-index to the input sub-index, showing the result of innovation activity in relation to the expenditure incurred.

In the years 2014–2021 a process of convergence of the innovation efficiency ratio in the four studied economies was noted. The values of this ratio in the entire study period were higher for China and Poland as compared against the scores of the

EU and US. However, it may reflect a relatively low level of innovation ability of the Chinese and Polish economy.

Figure 3. Values of the innovation efficiency ratios of China, Poland, EU and US in 2014–2021



Source: self-reported data based on the data from European Innovation Scoreboard 2021.

Analysis of the healthcare sector and pharmaceutical industry in the EU, including Poland, as compared against the United States and China

One of the main factors of the healthcare system functioning is health expenditure which significantly affects people's wellbeing and the economic growth of countries and is closely related to the economic growth both in the developing and developed countries [Lopreite, Zhu, 2020]. Comparing health expenditure in various economies is difficult as each country possesses its own set of political, economic and social conditions. Healthcare systems in various countries have different organisational structures and regulatory frameworks of insurance, as well as payment mechanisms for hospitals and doctors. Moreover, relations between the expenditure on goods and health services and total expenditure in the economy change over time, which is the result of rising health spending as compared to overall economic growth [OECD, WHO, 2020]. One of the significant factors affecting the provision of health services in particular countries is the volume of healthcare spending in relation to GDP [e.g. Wang et al., 2021]. Long term comparison of current healthcare spending as a proportion of GDP *per capita* in China and Poland as compared to the US and EU has been presented in Table 2.

Table 2. Current healthcare spending in China, Poland, EU and US in 2000–2018

Country	2000	2005	2010	2015	2016	2017	2018	Δ (2000–2018; %)
% GDP								
China	4.47	4.14	4.21	4.89	4.98	5.15	5.35	19.7
Poland	5.30	5.81	6.42	6.40	6.54	6.56	6.33	19.4
EU	8.43	9.07	9.88	9.94	9.93	9.88	9.85	16.8
US	12.54	14.61	16.35	16.71	17.05	17.00	16.89	34.7
Per capita, PPP (current international dollar exchange rate)								
China	129	208	381	702	759	838	935	625.6
Poland	564	807	1353	1717	1851	1979	2015	257.0
EU	4564	6455	7930	9491	9878	10 210	10 624	132.8
US	1814	2388	3178	3695	3869	4075	4206	131.8

Source: self-reported data based on the data from World Development Indicators (World Bank base).

The highest level of current spending on healthcare in relation to GDP, and per one citizen, is found in the US. The US is followed by EU treated as a whole in the study. It confirms that wealthy countries spend more on healthcare and the related costs per person than lower income countries. Nevertheless, a strong rise in healthcare expenditure can be observed in all studied economies. One of the reasons are the Grand Challenges aimed at supporting innovation in order to address critical health and development problems of the world, including ageing populations and civilisation diseases.

Pharmaceutical industry, driven by innovation, plays a vital role in developing healthcare systems [Schuhmacher, 2013]. They are of paramount importance from the point of view of the present and future progress in healthcare, which became particularly apparent during the COVID-19 pandemic. In the OECD classification, pharmaceutical industry is included as a technologically advanced sector [Hatzichronoglou, 1997]. One of the circumstances stimulating industry innovativeness is foreign trade which encourages higher efficiency through developing country specialisms based on their most efficient core competencies. Pharmaceutical industry's export market share in the studied economies has been shown in Table 3.

The highest export market share of the pharmaceutical industry can be observed in the US, which demonstrates economic advancement of this sector and overall innovativeness of the American economy. Yet, in the dynamic perspective, the US share in the export market of the pharmaceutical industry is slightly lower with a simultaneous increase of the Chinese economy in this respect. Poland lags behind the studied countries and does not have any specialism in the pharmaceutical industry. It confirms a general trend in the Polish economy to focus on low and medium low technology industries, with very low proportion of companies operating in high technology sectors, including the pharmaceutical industry.

Table 3. Share of the pharmaceutical industry in export markets of China, Poland and US in 2000–2019

Country	2000	2005	2010	2015	2016	2017	2018	2019	Δ (2000–2019; p.p.)
China	1.76	1.43	2.22	2.54	2.52	2.66	2.76	2.62	1.19
Poland	0.15	0.20	0.45	0.58	0.54	0.76	0.60	0.57	0.38
US	12.13	9.22	9.03	9.64	9.28	8.47	8.13	8.67	−0.55

Source: self-reported data based on OECD.Stat.

Characteristics of the Polish pharmaceutical industry

Pharmaceutical industry is one of the strategic sectors in the Polish economy. It is composed of companies manufacturing medicines and active ingredients for medicines. They perform an important economic role and have very special social significance as suppliers of life and health saving drugs. It becomes even more meaningful in the light of the changing demographic structure in Poland. It is forecast that the share of people over 60 in the general population in Poland will account for 30% in 2030 [Program, 2014].

Economic value of the pharmaceutical industry is confirmed by its share in generating GDP or creating work places. According to the report published by a team of researchers from the University of Lodz in 2020 the production of pharmaceutical goods accounts for 0.79% of GDP and 0.76% of work places in Poland.

However, the report also finds out that the share of the domestic pharmaceutical sector in the Polish GDP is decreasing, which means this industry is increasingly dependent on international supplies [Przybyłowski, Świerczyńska, Trębska, Gorzałkowski, 2020]. When studying the significance of the pharmaceutical industry, the indirect and income effects need to be noted. The indirect effect involves the GDP value, number of employees and taxes generated in other sectors in connection with manufacturing indirect goods used by the pharmaceutical sector. The income effect derives from the fact that the added value generated in this industry stimulates additional demand which drives the economy [Przybyłowski et al., 2020]. A complete analysis of all aspects of the pharmaceutical industry's operations and significance goes beyond the scope of this study. Thus, the analysis below focuses solely on the structure and innovativeness of this economic sector.

There are 131 manufacturers of pharmaceutical products in Poland accounting for over 12.7 bn PLN of marketed production. Looking at the size structure of the companies in this sector, it may be seen that relatively high results are achieved by small businesses employing up to 49 people. Their share in the overall number of companies in 2020 accounted for 43.5%. These businesses accounted for a mere 2.6% of the total value of production sold generated in the pharmaceutical industry. Medium-sized companies, employing 50–249 people accounted for 34.3% of all businesses and generated 14.2% of the production sold. Large companies employing over 250 people and accounting for only 22.2% of the entire number of businesses in the sector have a dominant share in the marketed production of the pharmaceutical industry, reaching 64.2%. Similar regularities may be noted when analysing the share of particular company sizes in employment. The share of large companies in total employment in the pharmaceutical industry accounted for 75.3% while the share of small and medium companies amounted to 5% and 19.7% respectively. The value of marketed production of the pharmaceutical sector and structure of businesses in this sector in 2020 is shown in Table 4 and 5.

Table 4. Value of the production sold in companies of the pharmaceutical industry in 2020

Categories	Sold production value (m PLN)						
	total	2.00 and below	2.01–5.00	5.01–10.00	10.01–20.00	20.01–40.00	40.01 and over
Number of entities	131	22	23	12	17	16	41
Production sold (m PLN)	12 763.3	13.9	74.3	92.3	242.8	454.1	7232.2
Average employment (thousand)	24.3	0.5	0.4	0.7	1.4	1.4	19.4

Source: GUS [2021b, p. 37].

Table 5. Structure of companies in the pharmaceutical industry in 2020

Categories	Number of employees (share in the total number of companies; %)						
	total	49 and below	50–99	100–249	250–499	500–999	1000 and over
Number of entities	100.0	43.5	18.3	16.0	12.2	7.7	2.3
Production sold (m PLN)	100.0	2.6	4.0	10.2	2.2	35.1	26.9
Average employment (thousand)	100.0	5.0	7.0	12.7	23.7	30.0	21.6

Source: GUS [2021b, p. 40].

Innovativeness level of the Polish pharmaceutical industry

Innovativeness of an enterprise is defined as its ability and propensity to innovate. Innovation ability of an enterprise is its ability to create and apply/commercialise new ideas – innovative solutions. This is the spending-focused approach to innovation, when the key innovativeness measure is the volume of outlays incurred to finance research and development work.

Innovation position, on the other hand, is part of the output approach focusing on the effects of the innovation activity – a combination of social creativity with financial resources (in a particular economic and institutional setting) [Weresa, 2012, p. 32].

Innovation activity of an enterprise and its effects (the level of innovativeness) are affected by many internal and external factors.

Internal innovativeness factors are related to the company's competitive potential (factor competitiveness). Competitive potential is a sum of tangible and intangible resources needed by a company to build, maintain and enhance its competitiveness [Stankiewicz, 2003, p. 103]. Internal economic factors affecting innovation activity – and as a result – innovativeness of companies are such indirect factors as: accumulated human capital resources (knowledge and skills of employees); accumulated knowledge resources (measured by the spending on scientific research and the volume of employment in R&D departments); materialised knowledge resources (in the form of machines, equipment, buildings); external knowledge resources from the environment (acquired through cooperation); organisational resources and factors which are indirectly related to the level of innovativeness such as financial resources of enterprises affecting their ability to finance innovation; the size of an enterprise determining its level of tangible and intangible assets [Wziątek-Kubiak, Balcerowicz, 2009, p. 17].

External factors of innovativeness include: the country's innovation system, sources of innovation – consumers, suppliers and contractors, other business partners and competitors; scientific and technological institutions – universities, scientific and research institutes; institutions and organisations supporting innovation – technological parks and incubators, technological centres; local and regional environment [Stawasz, 1999, pp. 35–37; Lewandowska, 2018].

Pharmaceutical industry is one of the most innovative sectors. Following Eurostat's classification, it is included in the high technology area, which puts it next to the sectors manufacturing computers and electronics, optical products or space ships and similar machines. In their production processes, companies of the pharmaceutical industry employ cutting-edge technological achievements. Based on the data from the Main Statistical Office, it may be concluded that the pharmaceutical industry is a leader in the number of innovative companies. In 2018–2020 the share of innovative[1] and actively innovative[2] businesses in the total number of companies accounted for 53.9% and 63.1% respectively (Table 6). Moreover, 46.1% of all companies in the sector have launched new or improved products[3], and 40.4% of firms have implemented new or improved business processes[4]. These values are significantly higher than the results achieved by manufacturers of computers, electronics and optical products. The marketed production of the pharmaceutical industry is dominated by generic products, which is reflected in a relatively low share of revenue from the sales of new or improved products in the total sales revenue (10.9%). By comparison, this share in the industries manufacturing computers, electronics and optical products was significantly higher and amounted to 25.7%. In the characteristics of the innovation activity of pharmaceutical industry companies there are two highly positive aspects: cooperation with other companies and research institutions in the field of innovation[5] and using public subsidies for innovativeness[6]. In the years 2018–2020 as many as 39.3% of actively innovative companies cooperated with other entities, and 30.3% of firms used public subsidies (Table 7). Engaging in the abovementioned undertakings should be recognised as a very positive activity because it boosts innovativeness and competitiveness of the industry and the entire economy[7].

1 **An innovative company** in terms of product and business process innovation is "a company which in a given time period launched at least one product or business process innovation (a new or improved product or a new or improved business process)" [GUS, 2021a, p. 27].

2 **An actively innovative company** is "a company which in the studied time period launched at least one product or business process innovation or implemented at least one innovative project which was interrupted or abandoned during the study period (did not succeed) or had not been completed by the end of the period (i.e. is being continued)" [GUS, 2021a, p. 27].

3 **Product innovation** is "launching a product or service which have new or improved features or application. These involve major changes in technical specifications, components and materials, built-in software, ease of use or other functionalities. Product innovation may be a result of applying new knowledge or technology, also creating new applications or combinations of the existing knowledge and technology" [GUS, 2019, p. 39].

4 **Business process innovation** is "implementing new or improving the existing business processes in a company within one or many business functions, which significantly transforms the business processes applied to date" [GUS, 2019, p. 39].

5 **Cooperation in innovation activities** represents active participation in implementing joint projects with other enterprises or non-profit institutions. It may be prospective and long term and does not have to entail direct and measurable economic benefits for the participating partners [GUS, 2019, p. 77].

6 **Public subsidies for innovation activity** may be provided by domestic institutions (including local and central level units) or by the European Union (including the framework programme Horizon 2022) [GUS, 2021a, p. 69].

7 It should be noted that there exist numerous barriers hindering cooperation between pharmaceutical companies and the research sector, which was pointed out in *Strategia rozwoju krajowego przemysłu farmaceutycznego do roku 2030* [Development Strategy of the Domestic Pharmaceutical Industry until 2030, Institute for Market Economics, 2013, p. 53–54].

Table 6. Innovation activity of pharmaceutical industry companies in 2018–2020 (%)

Categories	Share of companies in the total number of companies
Innovative companies	53.9
Actively innovative companies	63.1
Companies which have implemented new or improved products	46.1
Companies which have implemented new or improved business processes	40.4
Companies which have implemented new or improved products and business processes	32.6
Total new or improved product sales revenue	10.9

Source: GUS [2021a, p. 33, 53].

Table 7. Public subsidies and cooperation in innovation activity of actively innovative enterprises in the pharmaceutical industry (%)

Categories	Share of actively innovative companies
Actively innovative companies which received support for innovative activity	30.3
Actively innovative companies which cooperated with other enterprises or scientific institutions in innovation activity	39.3

Source: GUS [2021a, p. 70, 77].

The above presented data lead to the conclusion that the Polish pharmaceutical industry is a definitive EU leader in terms of its share of innovative companies. Reliable assessment of an industry's innovativeness requires a more thorough analysis comparing the volume of outlays on R&D work against other countries, which is the focus of the following part of this study.

Analysis of innovativeness of Polish pharmaceutical industry companies as compared against other European Union countries

The aim of this analysis, based on the harmonised Community Innovation Survey (CIS) for 2016–2018, is to study the innovativeness of the Polish pharmaceutical industry as compared against other EU countries.

The method of researching and classifying innovation for the CIS survey is based on the solutions proposed in the newest edition of the *Oslo Manual* (2018), prepared by OECD and Eurostat specialists.

In the 11th edition of CIS 729 301 companies representing particular sectors of the economy (NACE A – N) from 27 European countries were surveyed, 366 758 of which (a half) stated to have implemented a product or business process innovation in 2016–2018 (they were qualified as actively innovative companies). The entire study group (including companies from Iceland, Norway, Switzerland and Turkey) amounted to 866 516 entities, 423 356 (49%) of which stated to have implemented a product or business innovation.

In Poland a total of 62 048 companies were studied, 14 675 (24%) of which stated to have implemented some product or business innovation in 2016–2018.

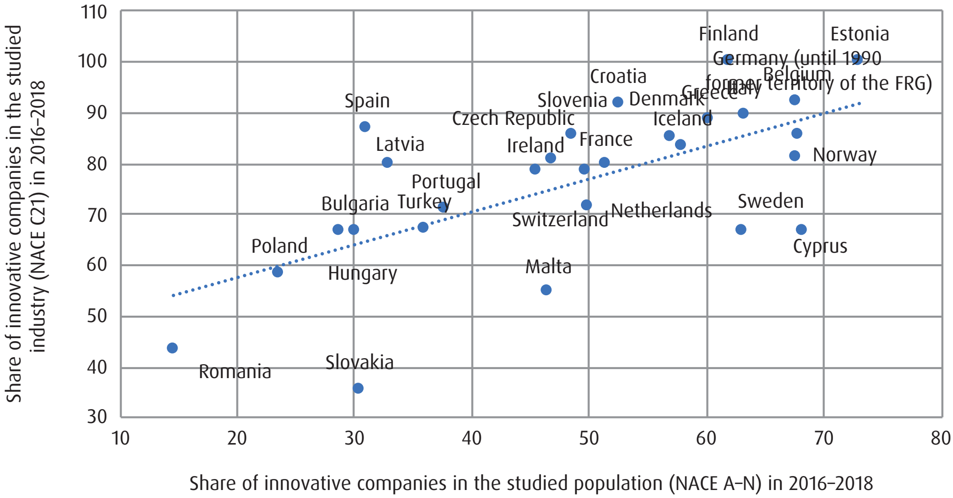
Unfortunately, information on companies from the pharmaceutical industry (C21 – production of basic pharmaceutical products and formulations) is incomplete – there are no data from Austria, Lithuania and Luxembourg.

The entire population of C21 industry is 2120 entities, 1663 (78%) of which stated to have implemented some product or business innovation.

The Polish C21 industry was represented by 125 entities, 73 (58%) of which stated to have implemented some product or business innovation.

Figure 4 shows data sets for the pharmaceutical industry versus the entire company population studied.

Figure 4. Proportion of innovative companies in the studied population overall (NACE A–N) and proportion of innovative companies in the studied industry (NACE C21) in the years 2016–2018 – data for selected European countries (%)



Source: self-reported data based on the data from the Community Innovation Survey for 2016–2018 (Eurostat's base).

A strong correlation is visible between company innovativeness in particular economies generally, and innovativeness in the pharmaceutical industry. It is worth noticing that the average level of the pharmaceutical industry innovativeness is two times higher than the innovativeness ratio of other companies in the economy overall. Detailed data for selected European countries have been set out in Figure 4.

Among the countries of Central and Eastern Europe it is Romania, Poland, Slovakia, Hungary and Bulgaria that have the weakest results on both ratios, and Estonia that scores the highest (although its studied companies' population was small accounting for only eight entities from C21 industry).

Due to natural constraints of the study, in the analysis of the innovation activity of companies from the EU pharmaceutical industry which in a given period of time implemented a product or/and business process innovation or conducted innovation activity that had been interrupted, abandoned or unfinished, two factors will be considered: the internal factor – expenditure on innovation[8], and the external factor – taking up cooperation in innovation activities by companies which in a given time period implemented a product or/and business process innovation.

In order to calculate the innovation budget per one company, the innovation budget declared for the entire industry was divided by the number of innovative companies which in the study period implemented a product and/or business process innovation.

For the cases of cooperation in innovation activity, a declared average result for the entire industry in a given country was used. It must be remembered that the result may have different values, depending on the size of the enterprise and other factors, and is always an average figure.

The volume of spending on innovation and cooperation in innovation delineates the position of circles representing pharmaceutical industries from the studied countries. The size of these circles represents the size of the population of innovative companies (the number of entities which declared having implemented a product and/or business process innovation or conducted an interrupted, abandoned or incomplete innovation activity).

Based on the data from Figure 5, it may be clearly concluded that the average declared innovation budget is the highest in pharmaceutical companies in Denmark,

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8 **Financial outlays incurred on innovation activity to create product and business process innovations** constitute the current and investment expenditure on product and business process innovations incurred in a reporting year on the innovation work which was implemented, the work which was not completed (is being continued) and the work which was discontinued or abandoned before completion, irrelevant of the source of financing. These involve R&D work, own personnel working on innovations (gross remuneration plus payroll charges), materials and external services purchased to conduct innovation activity, investments in fixed assets, other outlays on launching new or improved products or business processes [GUS, 2019, p. 58].

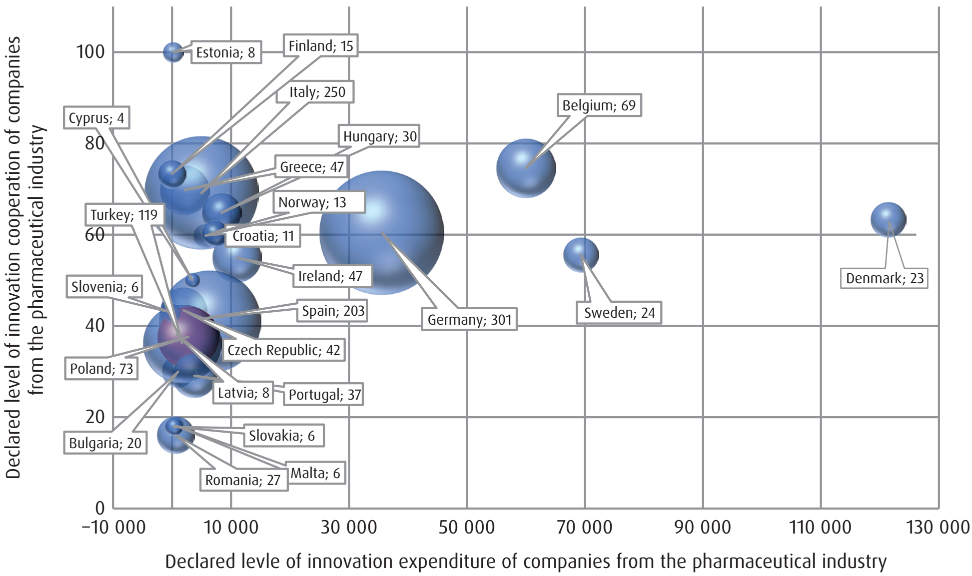
followed by those in Sweden, Belgium and Germany. The lowest average expenditure on innovations was found in companies from Romania, Malta and Slovakia.

Leaders of the declared cooperation in innovation are pharmaceutical companies from Estonia (100% declarations), Belgium and Finland. The weakest results in this respect were found again among the entities from Romania, Slovakia and Malta.

Polish pharmaceutical companies, in terms of the average innovation budget, are positioned among countries such as Portugal, Lithuania, the Czech Republic, Spain or Slovenia. The declared cooperation in innovation shows similar results.

The comparison of Polish pharmaceutical companies to the leaders of both rankings – Danish companies leading in innovation expenditure, and Estonian companies representing the highest level of cooperation in innovation – indicates that the average declared innovation budget of a Polish enterprise from the pharmaceutical sector accounts for slightly over 2% of the average budget of a Danish firm, while the level of cooperation is 2.5 times lower than this declared by Estonian companies.

Figure 5. Declared level of innovation spending (innovation budget) in 2018 (thousand EUR) and declared level of cooperation in innovation activity of companies from the pharmaceutical industry (%) in selected European countries



Source: self-reported data based on data from the Community Innovation Survey in 2016–2018 (Eurostat base).

It shows very clearly that in terms of these two highly significant variables determining innovativeness we are still behind the leaders, although it should be also admitted that the position of the Polish pharmaceutical industry, as compared to other EU countries, also these in our region, is stable, which is a good starting point for raising this level of innovation further.

Summary

The aim of this study was to assess the level of innovativeness and competitiveness of the healthcare sector and pharmaceutical industry in EU, including Poland, in an international contrastive study including two large world economies – the United States and China. The problem was discussed at three intertwining levels and employed the method of empirical analysis.

Macroeconomic analysis which studied the level of innovativeness and competitiveness of EU economies (particularly in healthcare and the pharmaceutical industry), also of Poland, as compared against the United States and China, indicates clearly a significant convergence (catching up with) not only in Poland, but most of all in China, in terms of sub-indices determining the innovation ability and innovation position of economies.

Based on the mesoeconomic analysis, which studied the condition of the healthcare sector and pharmaceutical industry in EU, also in Poland, as contrasted against the results of the United States and China, it may be stated that a dynamic rise in health expenditure in all studied economies was observed, although the highest level of current healthcare expenditure in relation to GDP and per one citizen is still found in the United States. The second place is occupied by the EU as a whole.

Microeconomic analysis, which was aimed at studying the level of innovativeness and competitiveness of Polish pharmaceutical companies and then comparing it to the results of other EU countries, finds out that the Polish pharmaceutical industry is a leader in the share of innovative companies in the entire industry. Also the declared level of cooperation in innovation activity remains higher than in the entire Polish economy. Nevertheless, Polish companies occupy a medium-range position among other EU companies, due to the average declared innovation budget which places them among entities from Lithuania, the Czech Republic, Portugal and Slovenia. In terms of innovation expenditure there exists a wide gap between Polish enterprises and those from Denmark, Sweden and Belgium.

Also the declared level of innovation cooperation, although high as compared to the Polish economy at large, when contrasted against other pharmaceutical companies from EU countries should be assessed as average.

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THE ROLE OF LEASING IN FINANCING ENTREPRISE INVESTMENTS IN CENTRAL AND EASTERN EUROPEAN COUNTRIES – CURRENT SITUATION AND FUTURE TRENDS

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Abstract

This study assesses the importance of leasing in financing corporate investments in CEE countries through the prism of the scale of this financing, as well as the future directions of using leasing to finance various types of assets. The key trends in changes in the leasing industry were also presented, including the development of a circular economy strategy, changes caused by the COVID-19 pandemic and the war in Ukraine, the effects of digitalisation, automation and robotisation, and electromobility. The study also assessed the growth potential of leasing in Poland and factors that affect it.

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Leasing is one of the key sources of financing company investments in Poland and other countries of Central and Eastern Europe (CEE). It is demonstrated by the fact that after 2017 the total value of the active leasing company portfolio in Poland was higher than the value of investment loans made to companies. The situation looks similar in other countries of CEE, as shown by the research findings among entrepreneurs which indicate that leasing, next to investment loans, is viewed as one of the two key financing sources for enterprises operating in this region of Europe.

The leasing market is undergoing major transformations driven by the trends of technological and regulatory changes on one hand, and of external shocks and macroeconomic circumstances on the other, which has strongly affected CEE economies in recent years. Among the technological and regulatory changes, an important role is played by digitalisation and economic automation, as well as increasing significance of low-emission technologies, which can be seen in dynamically developing electromobility and rising popularity of the circular economy. These changes are also reflected in the increasing role of the so called sharing economy or increasingly frequent Product-as-a-Service (PaaS) deals in the subscription model, including leasing agreements. External shocks and macroeconomic circumstances involve first of all the consequences of the COVID-19 pandemic, secondly the effects of the Russian aggression on Ukraine, leading to supply chain disruption and other production chain problems. Thirdly, leasing development has been also affected by the macroeconomic situation in terms of the aforementioned shocks which resulted in rising inflation and interest rates, and consequently, growing costs of credit – an important factor for corporate investments.

Taking the above into account, the aim of this study is three-fold. First, we aim to assess the importance of leasing in financing company investments in CEE countries through the lens of the scale of this financing, as well as directions of using leasing to finance various types of assets. The second goal is to identify and describe key change trends in the leasing industry in the present moment and the near future perspective. The third purpose is to evaluate the leasing market growth potential in Poland and to explain its determinants.

The structure of the study has been subjected to achieving those goals. The first two sections describe the leasing market in Poland and CEE countries as well as the significance of leasing in financing company investments. The third section is devoted to discussing key change trends on the leasing market. Section four includes an assessment of the growth potential of leasing in Poland and explains its determinants.

Leasing market in Poland and other Central and Eastern Europe countries

In recent years, the value of the leasing market has been systematically on the rise in most CEE[1] countries (Table 1). The year 2020 was an exception, when due to an outbreak of the COVID-19 pandemic and introducing new restriction, the value of leasing companies' portfolio expressed in the euro has shrunk in most countries of the region. In some cases it was caused by the domestic currency depreciation against the euro. In the studied period among CEE countries the Polish market was dominant in terms of the value of the leasing companies' portfolio (54.5–59.1% of the portfolio value of all countries in the region in 2016–2020). The second and third place was occupied in turns by Hungary (7.2–8.4% of the portfolio value in 2016–2020) and the Czech Republic (6.8–10.2% of the portfolio value in 2016–2020). The other CEE countries are much smaller than Poland, both in terms of the geographic area as well

1 Romania is not part of Leaseurope and there were no comparable data, so it was not included in the analysis.

as the size of the population and the domestic market, therefore the size of the leasing company portfolio alone cannot accurately represent the importance of leasing as a source of financing companies in particular countries of the region.

Table 1. Value of the leasing company portfolio (m EUR) and its structure (%) in CEE countries in the years 2016–2020

Country	2016		2017		2018		2019		2020	
	m EUR	%	m EUR	%	m EUR	%	m EUR	%	m EUR	%
Bulgaria	1694.6	3.8	1842.6	3.6	2064.5	3.4	2194.8	3.5	2202.9	3.6
Croatia	–	–	–	–	2015.2	3.4	2299.4	3.6	2155.1	3.5
Czech Republic	4504.2	10.2	4784.4	9.5	4868.5	8.1	4504.7	7.1	4147.0	6.8
Estonia	2322.0	5.3	2529.0	5.0	2755.0	4.6	2787.0	4.4	2681.0	4.4
Lithuania	1967.0	4.5	2567.0	5.1	2951.0	4.9	3001.0	4.7	2809.0	4.6
Latvia	1343.5	3.0	1562.2	3.1	1676.9	2.8	1731.0	2.7	1527.0	2.5
Poland	24 079.4	54.5	28 034.9	55.5	34 393.2	57.4	37 322.6	58.7	36 157.2	59.1
Slovakia	2676.0	6.1	2817.0	5.6	2801.0	4.7	3040.0	4.8	2911.0	4.8
Slovenia	2034.0	4.6	2114.5	4.2	2101.9	3.5	2088.5	3.3	2008.3	3.3
Hungary	3542.3	8.0	4268.2	8.4	4324.5	7.2	4616.6	7.3	4591.3	7.5
TOTAL	44 162.9	100	50 519.8	100	59 951.5	100	63 585.6	100	61 189.8	100

Source: self-reported data based on Leaseurope data.

Table 2. Value of the leasing company portfolio as a proportion of GDP in market prices in 2016–2020 (%)

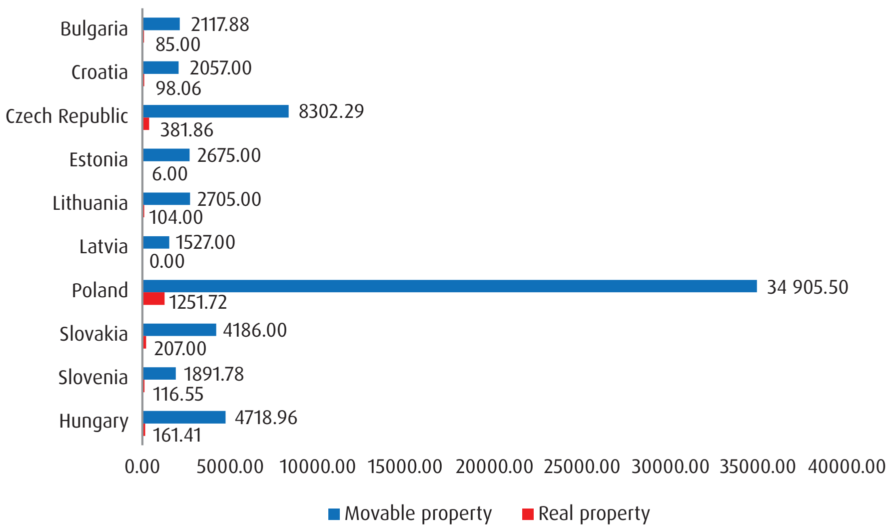
Country	2016	2017	2018	2019	2020
Bulgaria	3.47	3.51	3.67	3.57	3.59
Croatia	–	–	3.82	4.14	4.29
Czech Republic	2.54	2.46	2.31	2.00	1.93
Estonia	10.68	10.61	10.67	10.05	9.99
Lithuania	5.06	6.07	6.48	6.14	5.67
Latvia	5.3	5.79	5.75	5.65	5.18
Poland	5.64	6.00	6.91	6.99	6.9
Slovakia	3.3	3.34	3.13	3.23	3.16
Slovenia	5.03	4.92	4.58	4.32	4.28
Hungary	3.05	3.36	3.18	3.16	3.34

Source: self-reported data based on Leaseurope and Eurostat data.

The significance of leasing as a way of financing investments for companies in CEE countries is better reflected by the ratio calculated as a relation of the leasing firm portfolio (in EUR) to the GDP in market prices (in EUR) (Table 2). In the years 2016–2020 it reached the highest value in Estonia (ca. 10–11%). Poland followed Estonia in the second place (ca. 5.5–7%), overtaking Lithuania (since 2017 ca. 5–6.5%) and Latvia (ca. 5–6%). In other CEE countries the share of the leasing company portfolio in GDP expressed in market prices in 2020 did not exceed 5%.

The structure of the active leasing company portfolio in terms of the leasing object is similar in all countries of the region (Figure 1). Companies in CEE use this source to finance their movable property (vehicles, machines and equipment). The role of leasing for real property is quite insignificant.

Figure 1. Structure of active leasing company portfolio in selected CEE countries in 2020 (m EUR)



Source: self-reported data based on Leaseurope data.

In Poland (Table 3), just like in other CEE countries, leasing is mostly used to purchase movable property (about 99% of the value of newly signed agreements in 2016–2020). After the slump caused by the COVID-19 pandemic, the value of new leasing agreements for the purchase of movable property recovered in 2021 to the pre-pandemic level. The most popular movable property to be financed by leasing is the purchase of vehicles. In the years 2016–2021 about 66–74% of the value of new agreements was for this category of assets. The second leased asset category in terms of the value of contracts are machines and equipment (about 22–29% of the new agreements in the studied period). The share of other leased asset categories does not exceed 1.5% of the value of the agreements signed.

The most popular type of vehicles financed by leasing are light vehicles. Their share in the structure of leasing purchases in the last three years has increased from 37.7% to 41.1% of the new agreements value, even despite a limited supply of new passenger cars and delivery vans up to 3.5 tonnes in 2021 due to shortages of semiconductors. Leasing is at the same time becoming increasingly popular as a source of financing for the purchase of heavy goods vehicles – a record value of agreements for this category of vehicles in the last six years was reached in 2021. For a few years now, a downward trend is observed only in the annual value of new leasing agreements for the purchase of buses.

Table 3. Structure of purchases using leasing in Poland in 2016–2021 (net value, m PLN)

Leasing object	2016	2017	2018	2019	2020	2021
Vehicles	40 613.4	47 315.8	58 473.6	52 659.3	46 203.2	56 973.1
Passenger vehicles	19 992.1	25 581.3	34 288.1	29 320.5	27 343.4	31 760.8
Heavy goods vehicles up to 3.5 t	4436.7	4946.9	5654.1	5942.8	5924.6	6282.9
Heavy goods vehicles	15 810.1	16 343.3	17 983.3	16 999.9	12 453.4	18 176.1
Heavy goods vehicles over 3.5 t	2518.9	2804.5	3391.7	3404.5	2876.9	3714.1
Tractor units	8528.4	8647.0	9303.9	8890.2	6268.0	9356.5
Semitrailers/trailers	3423.5	3528.6	3955.2	3663.1	2662.9	4609.5
Buses	1339.2	1363.3	1332.5	1042.1	645.5	495.9
Other vehicles	374.5	444.3	548.1	396.0	481.8	753.4
Machinery and equipment	14 608.2	17 580.8	20 752.7	21 469.3	20 394.1	17 031.2
IT	727.2	880.1	966.4	1115.4	1035.0	856.1
Planes, ships and railway	1051.2	754.4	1008.4	1239.8	1012.8	1116.1
Other movables	360.2	373.3	446.1	512.2	571.0	525.1
Total movables	57 360.0	66 904.3	81 647.2	76 995.9	69 216.2	76 501.6
Real property	719.0	909.4	949.8	835.6	870.2	744.7
Total leasing	58 079.0	67 813.7	82 597.0	77 831.5	70 086.4	77 246.3

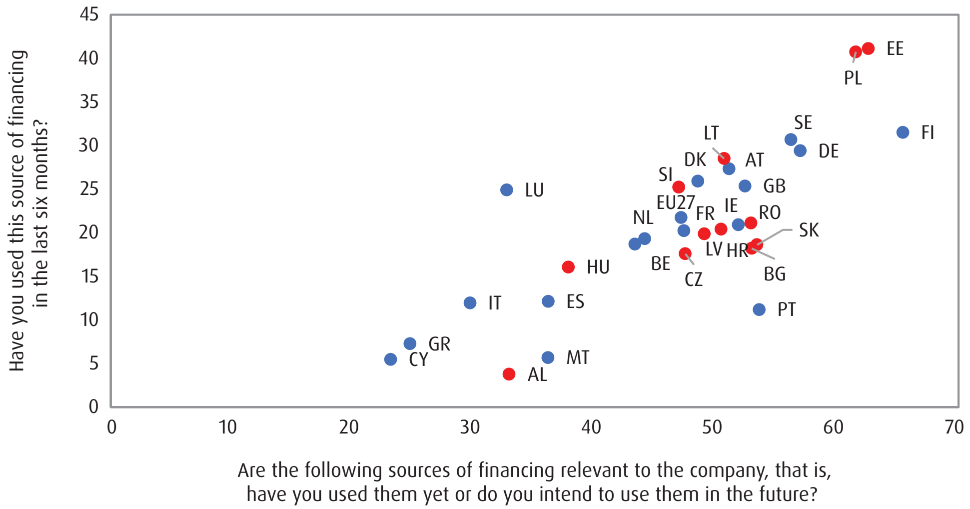
Source: self-reported data based on the Polish Leasing Association data.

To sum up, the Polish market is dominant among other CEE countries in terms of the value of the leasing companies portfolio. In the ranking presenting the relation of the value of the leasing companies portfolio to GDP in market prices, Poland occupies the second place preceded only by Estonia. In all countries of the region leasing is used mostly to finance movable property.

Significance of leasing for financing companies in Poland and other countries of Central and Eastern Europe

The significance of leasing for financing companies in Poland and other CEE countries as contrasted against countries of the European Union (EU) is presented in the findings of the Survey on the Access to Finance of Enterprises (SAFE) which monitors the access of European enterprises to various sources of finance. It is conducted yearly by the European Commission in cooperation with the European Central Bank. The last edition of the survey was performed on 6–13 October 2021. It studied 15 840 enterprises in total, including 4265 from CEE countries (944 from Poland).

Figure 2. Significance of leasing for enterprises in selected CEE countries versus EU countries in 2021



Note: colour red – EU member states from CEE region + Albania; colour blue – other EU member states + Great Britain.
Source: self-reported data based on SAFE 2021 data.

The data on the importance of leasing for enterprises in selected CEE countries versus EU countries were presented in Figure 2. The proportion of indications of leasing as a significant source of financing which companies have used or intend to use in the future is shown on the horizontal axis of the graph. The proportion of companies which have used leasing as a source of finance in the last six months was put on the vertical axis. The presented data allow to conclude that leasing is relatively popular in most CEE countries. According to respondents, in the last six months (April–September 2021) leasing has been most frequently used by entrepreneurs from Poland and Estonia (41% of respondents each), Finland and Sweden (31% each), Germany

(29%) and Lithuania (28%). At the same time, according to respondents, leasing as a source of financing will be used in the future by 65% of enterprises from Finland, 63% from Estonia, 62% from Poland, 57% from Germany, 56% from Sweden, 54% from Portugal and 53% from each Bulgaria, Romania and Slovakia. The presented data show that in the entire EU, leasing as a source of financing is the most popular in two CEE countries – in Poland and Estonia. In the predominant part of the region (Lithuania, Slovenia, Romania, Croatia, Latvia, Slovakia, the Czech Republic, Bulgaria and Hungary) leasing plays a similar role to that in other EU countries. Only in one of the studied CEE countries this source is not a popular method of financing companies – this is in Albania which is not an EU member.

Table 4. Importance of various sources of financing in selected CEE countries in 2021 (% of indications and position)

Country	Retained profit or sale of assets	Subsidies or subsidised loans	Credit line	Bank loans	Trade credit	Other loans	Equity	Leasing or rental	Position of leasing versus other sources
Albania	51.8	66.0	64.0	64.0	44.9	24.5	45.2	32.9	7
Bulgaria	44.5	48.0	61.0	48.0	40.2	37.0	3.8	53.0	2
Croatia	36.1	39.8	41.0	41.0	13.4	14.4	22.6	50.0	1
Czech Republic	29.3	37.0	50.0	39.0	15.1	23.9	2.0	47.0	2
Estonia	34.0	32.0	31.5	37.0	28.0	24.6	21.2	63.0	1
Lithuania	35.0	30.4	35.0	34.1	24.8	22.9	11.7	51.0	1
Latvia	44.0	29.1	37.3	28.3	19.4	31.0	43.0	49.0	1
Poland	21.9	42.0	52.0	37.6	38.7	17.3	5.1	62.0	1
Romania	26.8	47.0	60.0	36.9	33.9	26.0	10.7	53.0	2
Slovakia	32.1	16.3	56.0	42.0	24.5	20.8	2.7	53.0	2
Slovenia	22.9	36.5	48.0	43.0	14.6	17.9	23.1	47.0	2
Hungary	28.0	35.0	28.0	20.8	7.2	10.8	2.0	38.0	1

Note: according to the answer to the question "Are the following sources of financing important to the enterprise, that is, have you used them yet or are you going to use them in the future?" ($N = 3533$).

Source: self-reported data based on SAFE data.

High significance of leasing as a source of financing companies in CEE countries is confirmed by the data allowing to compare it against other sources of finance (Table 4). From among eight most popular sources of financing enterprises respondents most often mentioned leasing as the main form of financing (i.e. the method they have used already or intend to use in the future) in six CEE countries – Croatia, Estonia, Hungary, Latvia, Lithuania and Poland. In the remaining cases (except for Albania) leasing was positioned as the second most popular source of finance which entrepreneurs use or intend to use in the future.

In reality, over the last six months (April – September 2021) leasing has been the most often used source of finance for entrepreneurs from Estonia, Hungary, Lithuania and Poland (Table 5). In the next six CEE countries leasing occupied the second place among the most popular forms of financing enterprises in the said period. Only in two countries of the region – Bulgaria and Albania – entrepreneurs used leasing less frequently to finance their businesses.

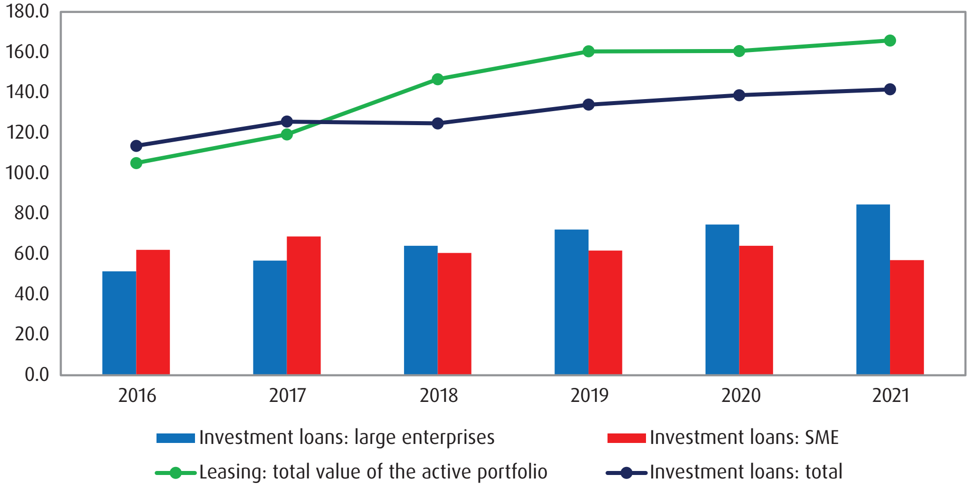
Table 5. Use of various sources of financing by SME in selected CEE countries in 2021 (% of indications and position)

Country	Retained profit or sale of assets	Subsidies or subsidised loans	Credit line	Bank loans	Trade credit	Other loans	Equity	Leasing or rental	Position of leasing versus other sources
Albania	27.0	6.0	27.0	11.0	3.0	11.0	8.0	4.0	7
Bulgaria	23.0	11.4	32.0	12.4	13.0	13.0	0.0	18.0	3
Croatia	18.0	9.5	26.0	13.9	2.0	6.0	0.0	20.0	2
Czech Republic	17.0	10.8	23.0	15.8	7.0	11.0	0.0	18.0	2
Estonia	11.7	11.2	17.0	10.2	18.0	12.0	1.0	41.0	1
Lithuania	23.0	11.1	21.0	11.0	16.0	10.0	3.0	28.0	1
Latvia	31.0	10.7	19.0	12.9	9.0	11.0	9.0	20.0	2
Poland	14.1	14.0	35.0	12.7	30.0	7.0	1.0	41.0	1
Romania	13.8	18.0	35.0	11.5	18.0	12.0	2.0	21.0	2
Slovakia	15.0	3.1	37.0	12.1	14.0	8.0	0.0	19.0	2
Slovenia	6.0	13.4	30.0	16.0	2.0	9.0	3.0	25.0	2
Hungary	10.9	14.0	14.0	7.0	2.0	5.0	0.0	16.0	1

Note: according to answers to the question "Have you used this source of financing in the last six months?" ($N = 3533$).
Source: self-reported data based on SAFE 2021 data.

In Poland leasing has been one of the key sources of financing for a long time now. In recent years overall value of the active leasing portfolio has been growing systematically (Figure 3) and since 2018 it has been higher than the total value of investment loans made to companies (according to the gross balance sheet value). Even the outbreak of the COVID-19 pandemic and the imposed restrictions did not negatively affect the value of the active leasing portfolio of leasing companies. According to the data from the Polish Leasing Association (ZPL), this source is chosen as a way of financing investments mostly by micro and small companies (i.e. with turnovers up to 20 m PLN) – these entities invariably constitute about 70–75% of leasing companies' clients. On the other hand, around 26–29% of companies with turnovers over 20 m PLN use the services of leasing companies. If we compare these data with the structure of investment loans and company sizes, we can note that leasing is chosen as a form of financing investments mostly by smaller firms (micro and small enterprises), while investment loans are preferred by larger entities.

Figure 3. Total value of the active leasing company portfolio versus investment loans made to enterprises in Poland in 2016–2021 (bn PLN)



Source: self-reported data based on NBP and ZPL data.

To sum up the above analyses, it should be stated that in most CEE countries leasing plays an important role as a source of financing companies. In many cases it constitutes the most vital form of financing investments. This has been the case in Poland, where leasing has been very popular among companies, particularly in the SME segment.

Key change trends on the leasing market in Poland

Circular economy: the sharing economy and product-as-a-service

One of the important trends affecting the leasing market in Poland is a rising significance of the operations paradigm of enterprises and markets adopting the model of the circular economy (CE), which is largely owed to EU policy assumptions and driven by the need to curb negative environmental impacts of economies. These changes involve, among others, establishing the principles of sustainable growth, striving to increase product durability, reusability, modernisation, repair, regeneration and developing product-as-a-service. The changes are increasingly often incorporated in particular policies, and consequently also in law-making [EC, 2020].

The trend of developing CE is of great significance for changes on the leasing market, as many of such strategies directly or indirectly involve using leasing or create new business opportunities for leasing companies. As indicated by Koide, Murakami i Nansai [2022], there are at least ten CE strategies, including servitisation, pooling, C2C sharing, rent, leasing, reuse, repair, modernisation/modularity, renovation/regeneration and durability. Many of them involve developing product service systems (PaaS) which use various practices of combining services and products based on the shift from selling products to using them on sharing and leasing platforms. It results in longer product life cycles through repairs, modernisation, reuse and regeneration or replacing goods with services [Cruz Rios, Grau, 2020; Schmidt, Malaschewski, Fluhr, Mörtl, 2015].

The abovementioned trends, being the results of CE implementation, have been confirmed during in-depth interviews with representatives of leasing companies. Switching to the circular economy model is also driven, in a wider perspective, by the implementation of the European Green[2] Deal strategy and rising costs of energy and fuels. These transformations are observable at various levels of the leasing industry operations. These involve for example:

- shifting from the model of goods ownership to goods use in the form of product-as-a-service (PaaS) and developing the sharing consumption;
- shifting from financing vehicles to financing mobility, including new forms of mobility – mobility-as-a-service (MaaS), mostly in cities;
- cooperating inside the value chain with manufacturers and combining the role of a manufacturer with that of a financial institution;
- developing the market of second-hand equipment – as a result leasing companies will become not merely providers of a product-as-a-service (passenger vehicles, public transport means, machines, equipment, etc.), but also entities engaged in the process of iterative product financing – where its life cycle comprises both the use and preparation for a reuse.

Participants of in-depth interviews stated also that these trends are not only strongly affecting the leasing industry, but will turn it completely around. Leasing

2 European Green Deal strategy was adopted in December 2019. It is a document which defines new EU economic growth priorities, where growth is treated as a separate area of activity and more efficiently using natural resources, with the ultimate goal of zero greenhouse gas emissions. The strategy provides for building a modern, competitive economy which prioritises the wellbeing of its citizens;

companies want to take part in this process by providing sustainable mobility, which involves the use of new types of vehicle drives, also the electricity powered ones. Sustainable mobility, apart from cars, pertains also to bicycles, scooters or motor scooters along with their comprehensive financing. One of the signs of this development trend in the leasing industry is the mobility budget financing – a budget granted to employees by the employer to cover various mobility needs. In this model, the employee can choose an optimal mobility means under mobility hubs offering various kinds of mobility instruments.

External shocks and their effect on leasing: value chains and cost of capital

Recent years have brought about powerful supply shocks which had very heavy but differentiated impacts on company operations and the Polish economic growth. COVID-19 pandemic on one hand caused significant constraints on some industries (catering, air transport, hospitality), on the other, created high demand for digital solutions and their increasingly frequent application in companies and by consumers. Moreover, the pandemic shock made many companies change their attitude to organising value chains by focusing more on localisation of these value chains and seeking higher delivery security [Radło, Sagan, 2021].

The current external shock of the Russian aggression on Ukraine resulted in a disruption of the supply chains, which drove the prices of energy resources and agriculture produce even higher. This, in turn, along with delayed tightening of monetary policy and loose fiscal policy during the pandemic caused a considerable inflation rise, followed by interest rate increases and as a consequence higher costs of external financing of company investments with bank loans [NBP, 2022].

Impact of the aforementioned external shocks on the leasing industry has been confirmed by participants of in-depth interviews. In their opinion:

- optimising and maximising the use of assets by companies has become more important; it is demonstrated in the tendency to extend the period of use and by leasing funds introducing some services provided as part of the long term machinery park management;
- occurrence of the shocks has enhanced the trends of the sharing economy model and PaaS;
- the pool of leasing objects (machines and vehicles) has shrunk due to disrupted supply chains, and as a consequence, often left companies completely cut off from the raw materials and components (during the pandemic and the war in Ukraine) used for the production of the leased assets;

- the pressure on digitalisation and localisation of supply chains intensified (particularly during the pandemic), currently there is also a lot of focus on automation in some industries due to shortages of the labour force (Ukrainians returning home to fight the war);
- there is more pressure on reusing the means of transport and machinery which have already run one leasing cycle; in order to tackle car shortages on the market the so called releasing has grown, giving vehicles a second life; in this model cars are rented on a subscription basis for a definitely shorter period, up to a few months maximum;
- the quality of loan portfolios has deteriorated as well.

Digitalisation, automation and robotisation

Automation and robotisation are trends which may have a double effect on the leasing market. Firstly, they may change the structure of the leasing objects – to more advanced, better suited to the automated production processes and provision of services, secondly, they may automate the very transactional process. Digital technologies may be applied at various stages of transactions on the leasing market. In this context special attention should be paid to the development of such technologies from the fintech sector as:

- artificial intelligence – employed in this industry to offer automated assessment of creditworthiness, create more intuitive user interfaces and better support for customer interaction;
- virtual reality – allows to deliver exceptional experiences to asset buyers (e.g. while buying cars) during visualisations and leasing object adjustments;
- blockchain – enables making fast and precise transactions in a way which optimises ecosystems and considerably diminishes the risk.

Moreover, among the available solutions, the application of Big Data by financial and leasing companies may lead to better and fuller understanding of customers, competitors, markets, products, services and channels.

In relation to digital initiatives, president of Netsol Technologies believes that leasing is one of the forms of financing which is particularly well suited to such undertakings [Najeeb Ghauri, 2022]. In his opinion, traditional lenders are less ready to offer financing due to regulatory constraints, thus companies turn to other models of financing, among which asset financing and leasing come to the forefront as the most profitable options to finance new equipment, vehicles and digital initiatives.

Each operational process, also the leasing process may be matched to an automated operational system, which may fundamentally change the way organisations function.

In leasing companies the key activity which may be handled using an automated system is the procedure of filing a leasing application. The application is usually passed through various departments and stages before it is authorised or rejected. Such work flows may be easily modelled in the system; what is more, based on the user-defined conditional reasoning (e.g. loan limits) the application may be transferred between different processes of the same activity. With the rise of advanced software tools it has become possible to automate entire leasing transaction procedures. Automation of the work flow in a leasing company allows to retain a high level of control over common processes performed by companies with limited control abilities. Additionally, the process may use some data stored in the system. It also ensures higher efficiency and access to large pools of data, additionally playing the role of a natural supervision and preparation tool for the entire organisation.

Five most important digitalisation trends which will affect the leasing market structure in Poland according to Allieron Fintech [2022], are:

- electronic signature, qualified electronic signature – modern e-leasing products should use the technological opportunities available; both the leasing companies and IT providers must be ready to supply this solution efficiently;
- eKYC and eID, the identification tools may be used in online communication with the public administration as well as while using e-services (e.g. financial or medical); processes connected to implementing eKYC pose many challenges to banks and institutions, handling them efficiently will significantly accelerate customer verification, thus reduce the number of rejected transactions;
- machine learning – in the financial sector this tool is used for automation purposes (e.g. in customer service processes); its application in leasing will speed up the process of filing applications and improve communication between deal parties;
- cybersecurity – security of data use and innovative authorisation tools are expected to improve the efficiency of leasing services.

Opinions of respondents of in-depth interviews and leasing market experts confirm that the pursuit of digitalisation and automation will significantly affect the development of the entire industry. The trend will most probably be observable in a long term perspective and will affect the way companies in the leasing industry operate as well as the very leasing objects themselves. In particular it will involve:

- increased demand for more advanced equipment, especially when SME sector is activated, as it holds a great innovation development potential which is, nevertheless, dependent on the support from economic policy;
- progressing industrial automation; for example cars connected in the IoT network, thanks to using telematics, will become wholly new devices than they are now, they will go beyond simply satisfying mobility needs; managing such a system requires

a different approach, but offers new opportunities; combined with artificial intelligence and Big Data it will generate new mechanisms in the leasing industry.

In the conducted study it was also observed that automation and digitalisation are motivated by the current market of the employee, which requires production process restructuring. In relation to the leasing industry it has a vital impact on the increased demand for new machinery and equipment which will replace human capital.

Development of the electric vehicle segment

The market share of electric vehicles (EV) depends not only on the technology and infrastructure of this form of mobility, but also on the adopted business model. Surveys of consumer preferences in making decisions about using electric vehicles [Liao et al. 2019] were conducted and they studied the following: battery leasing, vehicle leasing and mobility guarantees. According to them, preferences of business models depend on the type of vehicle: for battery electric vehicles (BEV) vehicle leasing is the most profitable option, and the least preferable – battery leasing, however, for conventional vehicles (CV) and hybrid plug-in vehicles (PHEV) a traditional full purchase model is usually chosen. This allows to draw some conclusions:

- firstly, leasing constitutes a real added value for BEV vehicles, while battery leasing is usually the least preferable business model, which makes it attractive only to a narrow user group;
- secondly, assessment of the vehicle leasing depends on the car type: contrary to BEV, people prefer to stick to one-time purchases instead of leasing with monthly repayments when using conventional vehicles and PHEV;
- thirdly, ensuring mobility guarantee for the period of up to two weeks a year does not considerably improve the attractiveness of BEV, thus it does not play an important role while making a decision as compared to other variables in the selection process.

Huang, Qian, Soopramanien and Tyfield [2021] studied consumer preferences in relation to three innovative business models on the electric vehicle market:

1) battery leasing,
2) electric vehicle leasing,
3) Business-to-Consumer (B2C) model and the traditional purchase model.

Survey findings allow to conclude that consumers perceive the models of battery leasing and electric vehicle purchase as close substitutes, while the models of electric vehicle leasing and sharing are seen as independent. Important financial factors are operational cost-savings in the model of battery leasing and general costs in the model of electric vehicle leasing. Key factors for choosing EV in the battery leasing model are the home charging option, vehicle licensing rules and accessibility of the charging stations.

Also the use of leasing and electric vehicle purchase at various stages of the product life cycle were studied. Findings of the study [Miao et al. 2016] lead to the following conclusions:

- for low priced EVs leasing is the right business model at the start and in the middle of the product life cycle; in the last 30% of the full life cycle it may be changed to purchase due to clients' risk-aversion;
- for medium-priced electric vehicles leasing is the preferred model for the entire life cycle;
- for high-priced electric vehicles the preferred model is purchase in the first 45% of the full life cycle before switching to the leasing mode.

Leasing market experts participating in in-depth interviews indicate that the electric vehicle segment already has and will have in the near future a significant positive impact on the industry. It is aided by the climate change agenda and the forecast dynamic electrification of vehicles. These trends will expand due to advanced work on hydrogen powered vehicles and autonomous cars. In-depth interviews also revealed a potential of demand for electric vehicles in the public sector, including territorial government units.

It is worth noting, though, that according to experts, the development of the electric vehicle segment depends not only on the technology, but also on the maintenance infrastructure of these vehicles, change in the relation of fuel and electric vehicle prices as well as the occurrence of some circumstances discouraging the use of traditional engines.

Potential of the leasing growth in Poland and its determinants

Respondents of in-depth interviews pointed out also to the leasing market development prospects both in Poland and across the CEE. They all agreed that the leasing industry had not reached its development maximum yet and there still was some room for market expansion. They indicated the following potential directions of growth: long-term rental, product rental treated as a service (PaaS) and opening of consumer markets. Dynamic growth of the latter segment depends on the possibility of executing agreements over the Internet (standardised agreements). There are also some risks resulting from provisions in consumer clauses, necessity of charging VAT on interest (limiting the attractiveness of the leased products) or application of abusive clauses. Moreover, in the consumer leasing segment the leasing object is not a transaction security, which drives up transactional costs.

Respondents were rather ambiguous about the growth potential of the property market. On one hand this segment is penetrated by leasing to a very limited degree (real property accounts for 1.5% of the value of leasing in Poland), which when compared with trends observable in some Western European countries (mainly France and Italy) allows to forecast further growth. Yet, taking all conditions of the Polish market into account, these forecasts may not come true. Factors halting the development of the property leasing segment include: long period of depreciation, tax conditions, difficulty estimating the value of currency in the long term and instability of regulations. Smaller leasing companies also fear the concentration on a few big transactions, which increases portfolio risk. Engagement of territorial government units and other public entities in the form of public-private partnerships constitutes a niche on the property leasing market.

Experts believe the following growth factors to determine the growth of the leasing market in the future:

- localisation of supply chains – causes the retention of foreign investments in Poland and CEE, which may result in the growing leasing market; manufacturing will be brought back from remote locations to the countries of the region;
- the employee market – it will stimulate automation/optimisation of production processes, which may boost demand for new machinery and equipment;
- development of e-commerce, including online commercial platforms (marketplaces) – means more demand not only for new services (e.g. digitalised platforms for handling leasing transactions, like Lease Link), but also for vehicles, which results from combined models of distribution;
- consolidation of many industries stimulated by rising energy costs, periodically also by the pandemic and other incidental changes – it is expected that rising costs of operations will cause the consolidation of many industries, which can stimulate large companies, at the same time destabilising SME sector.

The conducted in-depth interviews allowed also to identify negative factors affecting the leasing market in CEE. Rising interest rates and inflation are some of them. They cause leasing funds to migrate towards cash (with such changes government rescue packages do not offset the high cost of money). This effect is particularly visible among SMEs, while large companies remain more resilient to change and make investments according to long term plans.

Summary

The presented analysis had three research goals set for it and it has led to the following conclusions.

Having studied the importance of leasing in financing company investments in CEE countries, as well as directions for using leasing to finance various types of assets, it has been established that in Poland, like in other countries of the region, leasing is primarily applied to purchase movable property (ca. 99% of the value of new agreements signed, mostly to purchase vehicles, machinery and equipment). Generally speaking, leasing is one of the key sources of financing company investments in Poland and other CEE countries. In the opinion of entrepreneurs, leasing is perceived as one of the two basic sources of financing for companies. Among all EU countries, it is two CEE countries – Poland and Estonia that clearly stand out in this respect. As far as the structure of enterprises using leasing is concerned, it is chosen as a way of financing investments mostly by micro and small firms.

The purpose of this study was also to identify and assess key change trends in the leasing industry. Literature review and the conducted in-depth interviews allowed to define the following catalogue of modern trends that have an important bearing on the leasing industry: the circular economy, the sharing economy and product-as-a-service, incidental and shock changes, digitalisation, automation and robotisation as well as electric vehicle segment development. Many of these trends constitute a wider conception of sustainable finance.

All the indicated trends have been recognised as vital by industry experts.

The circular economy offers some opportunities for leasing companies to extend their offering with new fields of operations and shift from selling products to using them on sharing and leasing platforms. Increased interest in the circular economy model follows from a wider context of the European Green Deal implementation as well as rising energy and fuel costs.

The industry has been also shaken up by external shocks, bringing about higher significance of use optimisation and asset maximisation, popularising the model of the sharing economy and PaaS, also decreasing the pool of leasing objects, e.g. due to disrupted supply chains. According to experts it intensifies the pressure on digitalisation and localisation of value chains and reuse of means of transport and machinery.

Automation and robotisation are the trends which may have a double effect on the leasing market. Firstly, they may change the structure of the leasing objects to more advanced and better suited to the automated production and service delivery processes; secondly they may automate and digitalise the very transaction process. According to experts this trend will most probably have long term effects.

The technology of vehicle electrification has brought a special and very significant change to the leasing market. The conducted surveys have found out that the electric vehicle market share depends both on the availability of the technology itself and on of the infrastructure in this type of mobility and the business models implemented by companies.

Summing up the effects of the observed development trends on the situation of the leasing industry it can be stated that the described changes not only strongly affect the segment, but will turn it completely around.

The third goal of the study was to identify the growth potential of the leasing market in Poland and its determinants. Quantitative data analysis as well as experts opinions have confirmed the hypothesis that the industry has not reached its maximum potential in terms of the market expansion. Potential paths of the industry development involve: long term rental industry, rental of products treated as services and opening of consumer markets. Positive determinants affecting leasing development are: progressing localisation of supply chains, the employee market as a boost to automation and production process optimisation, dynamic growth of e-commerce and many industries' consolidation driven by rising costs of energy. The conducted in-depth interviews allowed also to identify negative influences affecting the leasing market in the CEE region. These include mostly rising interest rates and inflation, which means that leasing funds will migrate towards cash.

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THE NEW WORLD OF SHOPPING – TRENDS AND CHALLENGES FOR TRADE IN POLAND AND CENTRAL AND EASTERN EUROPE

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Abstract

The aim of the study was to analyse and evaluate challenges facing the retail sector in Poland and in selected countries of Central and Eastern Europe (CEE). First, the study presents an in-depth analysis of changes in the structure of the retail market in Poland and the countries of CEE. It evaluates the structural changes and conditions shaping the retail industry in the region, particularly the sales of food products, in the face of the COVID-19 pandemic and presents a forecast of the upcoming transformations and challenges in the sector under the changing post-pandemic conditions. Additionally, the study assesses the use of digital technologies in response to modern commercial trends and outlines major developments which have been turning around the industry. Findings of the empirical research into the changing demand for labour competencies in commerce have been explained, the role of technology in alleviating some of the workforce shortages has been discussed, and a prediction about the future skills needed in the retail industry has been provided. Moreover, the study offers an overview of the impacts the changing customer behaviour exerts on the industry.

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If there is just one thing everyone on the Planet could agree on today, it must be the fact that recent years have been filled with severe health and economic challenges caused by the COVID-19 pandemic. The pandemic had hit the retail sector heavily, but after many months of volatility – with restrictions being imposed, lifted and then put on again – some signs of a rebound could be observed. Last months have made it apparent that retail trade is an agile industry and can quickly respond to change by offering positive and promising growth prospects, where modern technologies can provide retail vendors with many functionalities as well as offer problem-free, engaging and personalised experiences to the customers across all sales channels – in-store, on-line and on mobile devices. Another asset of this industry is flexibility, allowing it to quickly respond to the changing consumer needs as well as the occurring economic trends and situations.

The aim of this study is to analyse and assess the challenges facing retail trade in Poland and the Central and Eastern Europe (CEE), evaluate the structural and corporate changes as well as trends affecting the retail industry, particularly in grocery trade which is undergoing a thorough transformation, forecast the upcoming industry turnaround paths, including the changing competencies of retail employees and the post-pandemic economic situation in the region. Countries included in the study were: Poland, Romania, Hungary, the Czech Republic, Slovakia and Lithuania. The selection of countries was underpinned with the following factors: their size and geographical location, market specifics and accessibility of the currently relevant data. The analysis employed an exploration-based approach. First, a comparison was made of the trade development levels and impacts of the COVID-19 pandemic on the industry in question in the selected CEE countries, also a study of retail employee competencies in Poland was carried out. The following descriptive part contains desk analysis, literature review and industry reports.

Analysis of the markets and structural retail industry changes in Poland and in the selected countries of CEE

The contemporary retail market is a smart, complex and agile system which comprises multiple sub-systems operating in various areas. From the point of view of the strategic development of modern economies, grocery retail trade plays a vital role in regulating market forces. Grocery products are the biggest segment of the food market in Poland, accounting for 65.5% of its value, which makes it a very important Central European market in the retail sector. By 2025 sales are expected to reach $70 429.2 m (Table 1), which represents an increase of 18.6% on 2020.

Table 1. Value of food sales in Poland in the years 2020–2025

Year	Sales value (m USD)	Change (%)
2020	59 387.3	
2021	58 903.5	−0.8
2022	60 831.3	3.3
2023	63 258.3	4.0
2024	66 792.8	5.6
2025	70 429.2	5.4
Accumulated annual growth rate		4.2

Source: self-reported data based on EMIS [2022].

Studying the data in Table 1, it should be stated that the average annual rise in food sales in Poland amounted to 4.2 p.p. It should be also noted that after a difficult 2021, marked by the pandemic hardships, the growth rate and food sales in Poland expressed in percentage points have been increasing year after year. In order to adopt a wider perspective on the analysis of the retail market in Poland, five other CEE countries have been studied: Romania, Hungary, the Czech Republic, Slovakia and Lithuania. Table 2 sets out the retail structure in terms of the number of sales outlets, net retail sales value, retail trade market share and changes in this share.

Analysis of the data from Table 2 allows to formulate a few conclusions. Firstly, the leading food retailer in terms of the net retail sales value in 2021 in Poland was Jeronimo Martins operating a total of 3 000 stores. A strong position of this discount store resulted directly from its fast adaptation to lockdown restrictions, running intensive price leadership campaigns as well as convenient store locations. The next position was occupied by Lidl, followed by the third player in terms of sales value – Eurocash Group which, along with Lewiatan (4th place), operated over 19 thousand stores in 2021.

Table 2. Structure of the retail market in selected CEE countries in 2021

No.	Largest retail chains	Number of stores	Net retail sales in 2021	Market share of retail trade in 2021 (%)	Change in market share in 2019–2021 (%)
Poland (m PLN)					
1	Jeronimo Martins Polska SA	3154	64.458	11.7	0.6
2	Lidl Sp. z o.o. Sp.k.	760	26.004	4.7	0.4
3	Eurocash SA1Grou^p	15 990	21.565	3.9	−0.2
4	Lewiatan Holding SA	3072	14.624	2.7	−0.1
Romania (m RON)					
1	Lidl Discount SRL	300	14.393	6.9	1.7
2	Kaufland Romania SCS	119	12.851	6.1	−0.2
3	Profi Rom Food SRL	202	10.116	4.8	1.0
4	Carrefour Romania SA	360	9.289	4.4	0.1
Hungary (m HUF)					
1	Lidl Magyarország	186	786.362	7.4	1.7
2	Spar Magyarország	588	674.073	6.3	0.2
3	Tesco-Globál Áruházak	201	588.440	5.5	−0.9
4	CBA Kereskedelmi Kft	1987	424.430	4.0	−0.5
Czech Republic (m CZK)					
1	Lidl Česká Republika	292	80.281	7.6	0.7
2	Kaufland Česká Republika	133	70.335	6.7	0.6
3	Albert Česká Republika	328	59.525	5.6	−0.1
4	Penny Market	395	46.978	4.4	0.3
Slovakia (m EUR)					
1	Coop Jednota Slovensko sd	550	1.701	8.9	0.5
2	Lidl Slovenská Republika vos	155	1.608	8.4	0.6
3	Tesco Stores SR as	154	1.505	7.9	−0.4
4	Kaufland Slovenská Republika vos	71	1.442	7.5	0.6
Lithuania (m EUR)					
1	Maxima LT UAB	245	1.768	17.2	−1.1
2	Palink UAB	228	709	6.9	−0.4
3	Lidl Lietuva UAB	368	612	5.9	1.1
4	Norfos Mažmena UAB	134	552	5.4	0.0

Source: self-reported data based on the unstructured data and data bases of Passport Gmid [Euromonitor, 2022a, 2022b, 2022c, 2022d, 2022e, 2022f].

1 Eurocash Group comprises the following stores: ABC, Delikatesy Centrum, Groszek, Euro Sklep, Gama.

Secondly, these players have taken over the market previously held by small-format stores, which causes small entrepreneurs to cluster into purchasing groups or buy into franchises [Business Insider, 2020]. It is also worth pointing out that discount stores, supermarkets and convenience stores which have been building up their position in large cities are simultaneously expanding into smaller towns and villages. Thirdly, having studied the above data, it can be noted that despite a highly competitive FMCG (Fast Moving Consumer Goods) market, many companies have been handling both the Polish and foreign capital very skilfully. Fourthly, optimising supply chain costs led to a significant lowering of product prices, and along with a suitably applied price strategy put the discount chain Lidl into a leadership position in terms of the income level in such countries as Romania, Hungary and the Czech Republic. In Lithuania Lidl is constantly trying to move the goal posts not only in the discount store segment, but also among innovative food retailers, thus creating a competitive environment for key players. It should be noted that the chain's market share has been rising in all the studied countries. It may be an interesting fact to see that the Tesco chain, on the other hand, has been losing market share in countries such as Hungary and Slovakia.

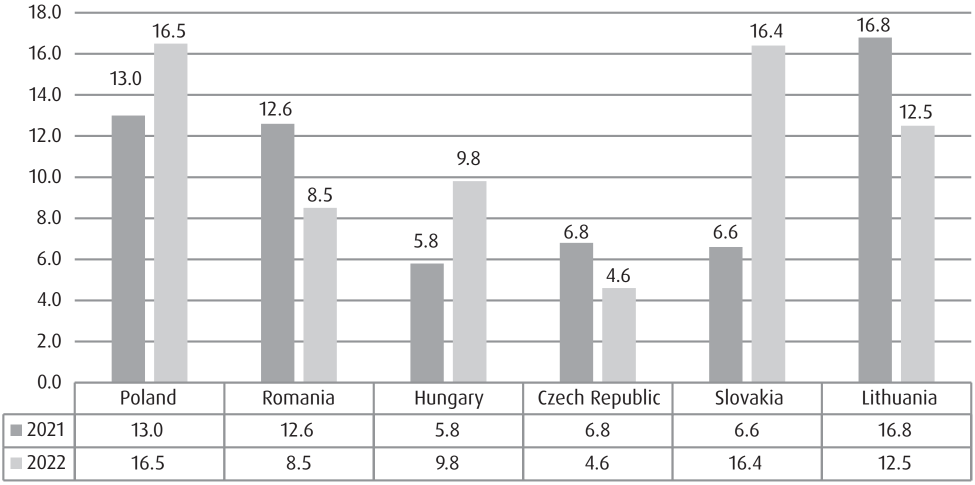
Similar to Poland, the structure of the retail trade in Romania underwent serious turbulences in 2021, switching from the traditional to more innovative forms of trade [Statista, 2022]. Five most powerful players on the Romanian market account for 72% of the annual retail sales [Agroberichten Buitenland, 2021]. To the contrary, the retail market in Hungary is one of the weakest sectors in CEE [Statista, 2021]. Independent CBA retailers together with COOP control one fifth of the Romanian market. The Czech market is characterised by a strong position of large international retail chains with no matching competitors on the domestic market. The situation in Slovakia is different, the food market in this country accounts for over a half of total retail sales [Trade, 2021]. The least attractive location for retail giants is Lithuania with its small population and territory.

Next, it is worth paying attention to the indicators of retail trade dynamics in the studied countries (Figure 1).

The analysis of data presented in Figure 1 allows to formulate the following conclusions. Firstly, in the studied period, retail trade dynamics increased y.o.y. in Poland, Slovakia or Hungary, and this increase was the most visible in Slovakia. The situation of the COVID-19 pandemic had a special intensifying effect on the buying trends in this country, the frequently imposed quarantine resulted in consumers quickly switching from bricks-and-mortar stores to the on-line channel with their shopping, driving the volume of food purchases made on the Internet. Secondly, a declining retail trade dynamic y.o.y. was recorded in Romania, the Czech Republic and Lithuania. It should be kept in mind, though, that despite this, Romania is still one of the

EU leaders in GDP growth which is driven by resilient private consumption leading to increased purchasing power of consumers in this country.

Figure 1. Indicators of retail trade dynamics in Poland and selected CEE countries in the years 2021–2022 (fixed prices)



Source: self-reported data based on Trading Economics [2022].

Defining the retail sector's market concentration (Table 3) is also an important aspect in retail market analysis.

Table 3. Concentration of retail trade in selected CEE countries

No.	Country	Characteristics
1	Poland	Polish retail market is unique and fast growing. Despite a high share of discount stores, as one of very few European markets, it retains an exceptionally high share of small-format stores, both members of franchising chains and independent, which makes this market quite fragmented.
2	Romania	Romanian retail market is highly diversified due to its high innovativeness and fragmentation. It is continuously growing and raising its competitiveness. Retailers must focus on competition, consumers and new technologies.
3	Hungary	Hungarian retail market is concentrated with the strongest position of local and cooperative stores.
4	Czech Republic	Czech retail market is highly concentrated. Strong and fast consolidation led to strengthening of the position of large international chains which do not face any domestic competition.
5	Slovakia	Slovak retail market is concentrated. It is highly sensitive to prices and competition.
6	Lithuania	Lithuanian retail market is fragmented. It is characterized by a low market share concentration (no retail companies holding more than 5% of the market share).

Source: self-reported data based on unstructured sources.

It interesting to observe that in countries such as: Poland, Romania and Lithuania the retail market is dispersed, as singular sales outlets are spread around cities as well as rural areas. In the remaining countries of the region which were included in the study the market is concentrated, which means that in one area there are various retail sales outlets. Among the countries with concentrated food markets, the position of retail entities is visibly stronger and the degree of trade consolidation is higher than in the countries with dispersed retail markets [Pańczyk, 2019]. In the countries with dispersed retail markets, retail entities tend to be more individualised, which allows retail chains to implement diverse strategies for winning new customers.

Evaluation of factors affecting the retail sector in Central and Eastern Europe during the COVID-19 pandemic

The COVID-19 pandemic brought about severe repercussions for the world economy not only in the short term, causing a global recession, but also triggering systemic and structural changes which follow from the natural adjustment processes. The world trade and international systems of production relations in global supply chains are the areas particularly exposed to the consequences of the pandemic. The scope of the pandemic caused governments to employ non-standard measures to attract investments by creating an infrastructure conducive to the trade exchange. Noticeably, commercial companies have been using various strategies to retain advantage in such a hypercompetitive environment. It has become paramount to monitor operating and financial results of the retail chains as well as to continuously watch diversified and fast-changing consumer needs.

The pandemic has undoubtedly transformed Poles' buying habits. So far, shopping has been recognised as a bit of a "national sport" of Polish people due to how frequently they go shopping, high numbers of customers visiting retail chains, as well as one of the highest ratios of the number of retail outlets per one citizen. The parameter of store visit frequency was a differentiating factor of Poles as compared against other European countries. A statistical Pole before the pandemic visited stores almost on a daily basis, which was a significantly higher result than observable in France or Germany. On one hand, the epidemic situation shrank bricks-and-mortar store visits as a result of the implemented lockdowns, on the other, the shopping basket value increased. According to experts, it was merely a transient trend. Consumers did their shopping at local retailers instead of travelling to more remote sales outlets. However, this situation encouraged retail chains to double their efforts in competing on the range of goods offered, prices and technological novelties in order to lure consumers.

Faced with rising prices, Poles tend to choose cheaper products and cut down on the grocery product consumption.

Commerce in 2022 has been challenged by the pressure on higher wages, increased minimum wage and tightening of the ban on Sunday trade. The retail sector has also suffered from taxation changes such as e.g. introducing the tax on sugary drinks and alcohol in small bottles – contrary to law-makers' promises these have not produced any health benefits, but caused major shifts in consumer decisions, particularly favouring other segments of alcohol beverages, which greatly affected the operations of retail trade. A similar challenge was also posed by the increasingly unpredictable legislative environment and heavier administrative burdens imposed on entrepreneurs. A good example may be implementing a new VAT rate without any adequate *vacatio legis* on some products in February 2022 as part of the so called anti-inflation shield – it disrupted the operations of retail outlets because abrupt changes had to be introduced in a very short time. Additionally, there occurred more demand for safe-origin and health-promoting products. To meet the demand, retailers started to put more healthy and organic products on the market, sourcing them from local suppliers.

On the Romanian retail market, the very attitude of customers to shopping has changed. Customer experience and attachment to a particular retail chain have become more important than the products themselves. Yet, the market continued to expand, driven by the geographical expansion of retail trade, rising share of own brands as well as optimised strategies and operational models. The lockdown time appeared to be a breakthrough period also because it brought about many shopping habits and consumption patterns created by sellers and consumers as ways of accommodating the difficult living conditions during the COVID-19 pandemic. Interestingly, consumers started to quit convenient online commerce for the sake of visiting physical discount stores during the pandemic.

The Hungarian retail market faces currently the challenge of price regulation. At the beginning of February 2022 regulated prices were implemented on selected food products based on the prices before 15.10.2021, which consequently led to shortages on store shelves and restrictions on the sales of certain product categories [Portal Spożywczy, 2022]. At the same time, this slump in the prices of certain products caused local shop owners to buy large quantities of them in hypermarkets which offered lower prices than wholesalers [Euromonitor, 2022b]. Modern grocery stores played a vital role in supplying consumers with food products during the pandemic crisis. Indirectly, it contributed to opening new retail chain outlets. On one hand, high proportion of the vaccinated population allowed to gradually open the market in mid 2021, and it boosted retail sales. On the other, though, some insecurities as to the future of the pandemic, long term changes in retail trade and shopping habits started to play up, which forced the implementation of new business models better fitting the existing market conditions and potential future epidemics.

In the Czech Republic during the pandemic a significant rise in the number of stores of the following brands was recorded: Lidl, Albert, Billa or Penny Market [Zboží and Prodej, 2022]. Yet, it did not affect the expansion plans of retail chains, as 56 new stores were established. Supermarkets, discount stores and hypermarkets were the beneficiaries of consumers switching from visiting restaurants to shopping in retail stores. Another clearly visible trend in the Czech Republic during the pandemic were large investments in food-to-go sections of retail outlets. Taking another perspective on that, it may be concluded that a small number of independent retail vendors will be able to implement an omnichannel strategy by launching innovations, thus they are likely to be losing ground.

The pandemic has also caused various changes on the retail market in Slovakia [Trade, 2021]. Switching to e-commerce was a major boost to using websites offering product price comparisons, such as: *pricemania* or *heureka.sk.* The category “food” was regularly searched by as many as 9% of citizens [Euromonitor, 2022f]. It should be noted that simultaneously the number of stores started to dwindle (by 4% on 2021). It is thus forecast that the thriving electronic and mobile commerce will permanently transform the retail landscape in Slovakia.

The Lithuanian retail market is one of the most important industries in this country – it employs as many as 12 in each 100 workers hired by Lithuanian companies. In February 2022 Lithuania reached one of the highest annual retail trade growth rates in the EU [Retailing in Latvia, 2022]. Similar to Hungary, loosening of restrictions combined with increased vaccination rates and lower infection figures had a positive effect on consumer confidence. Closing down of cultural and entertainment facilities and libraries drove up retail sales of grocery products, which encouraged the demand for food and beverages. Melting disposable income, along with increased economic uncertainty caused changes in buying preferences of consumers who frequently chose to shop at the stores offering value-for-money goods. A global healthy living trend resulted in launching many healthy food products of safe origins and adopting a more individual approach to customers.

To recap, in every studied country, the pandemic had a significant yet different effect on the retail industry. Restrictions imposed by local governments on store operations, shopping malls and the catering sector resulted in a changed consumer behaviour. A rise in the number of stores across all the studied countries was also recorded. However, it should be noted that discount stores which previously had been selling cheap, low-quality products, during the pandemic revolutionised their business, squeezing hypermarkets’ market share.

It seems that health and safety concerns will still pose a strategic challenge in 2022 after all the pandemic restrictions have been lifted. Expanding inflation will hold retail markets yet to another test all across the studied countries, giving rise to a further debate on the possible scenarios concerning the impacts exerted by the pandemic and inflation on the retail sector in the near future.

Using digital technologies in retail trade

Previously, technologies were not found vital in the food industry as compared to other functions like category or supply chain management. Over time, this approach has changed, as technologies and innovation became increasingly significant differentiation criteria for companies, chains and brands facing keen competition. The trend has been fuelled not merely by the role of online channels and new store technologies such as self-service checkouts, but also by the processes of the supply chain automation and retail back office mechanisation, which serve higher efficiency and productivity in running retail businesses.

Numerous modern companies have been increasing financial outlays on data analysis in order to optimise their product ranges and promotional tools. Advanced analytics, using Big Data, allows retail chains to switch from mass promotions to personalised offers and from harmonised product ranges to store-specific arrays. In order to expand their operations, food retailers must invest not only in technological solutions, but also in management skills which will enable them to include data knowledge into their operational processes and business models. Frequently, this leads to digitalising the entire management system of a retail business, which allows e.g. franchise shop owners to manage and change their product range and stock levels in real time in ways which correspond to the current consumer behaviour and local competitors actions. Moreover, solutions using Big Data or AI lead to better financial results of retail outlets due to optimised rotation and assisted product range management.

Although virtual reality is at a relatively early stage of development, companies have been experimenting, offering attractive virtual experiences while selling products – from clothes, through cosmetics, to furniture – in order to boost conversion and reduce returns. The employed solutions come at various levels of advancement. Some of them, like online consultations, virtual tutorials or live broadcasts, connect consumers with brands through digital platforms. Others are a few steps ahead, emulating the experience of physical contact or trying on products by using technologies like augmented or virtual reality.

Using artificial intelligence to optimise retail processes should make customer service fast, smooth and intuitive. For this purpose, information from various data bases, including CRM, is studied to create a 360-degree image of the customer and customer needs. Access to aggregate data derived from multiple channels allows companies to achieve advantage in terms of satisfying customer expectations.

Although electronic commerce has been the fastest growing channel for the past 15 years or more, many people are inclined to perceive the current crisis as a key factor for accelerating the transformation taking place in this field. The COVID-19 pandemic put many consumers in the situation where they had to do their shopping online for the first time, and those who had been savvy online shoppers before were inspired to buy more frequently by enjoying access to a wider product and service range. It should be noted that although traditional stores will remain an important channel of discovering and buying products, the new experiences of employing other forms of sales will stay with customers for longer.

Technology has been dismantling the existing physical and mental barriers, leading to the development of digital customer touchpoints and questioning the role of bricks-and-mortar outlets. These changes are reflected in retailers' strategic priorities. In order to maintain their position, companies must determine how the competing forces will affect the retail market section they occupy and then create forecasts for the best strategic development paths. One of the possible solutions are autonomous stores. It is difficult to predict now whether they will become popular enough to constitute an important element of the retail ecosystem or will remain just a niche. Apart from the technology itself, it will be customers' attitude to the new solution that will decide.

Very interesting new opportunities are currently offered by the advancing digital transformation, thanks to which companies can simultaneously automate many customer service and sales channels via telephone, Interactive Voice Response (IVR), electronic mail, websites, chatbots, social media, text messages or digital voice assistance based on artificial intelligence. Moreover, challenges of fighting the COVID-19 pandemic forced companies to speed up the implementation of digital technologies to ensure better customer experience.

It should be noted that retail trade is ready for automation – an estimated 50% of retail activities can be automated using the currently available technologies. Therefore, the skills needed by retailers to succeed in the future are a lot different from the competencies of the past. Present trends such as rising online sales and contactless service in physical stores have been accelerated by the COVID-19 pandemic, which determines how technologies will be implemented in the future.

Changing demand for employee competencies

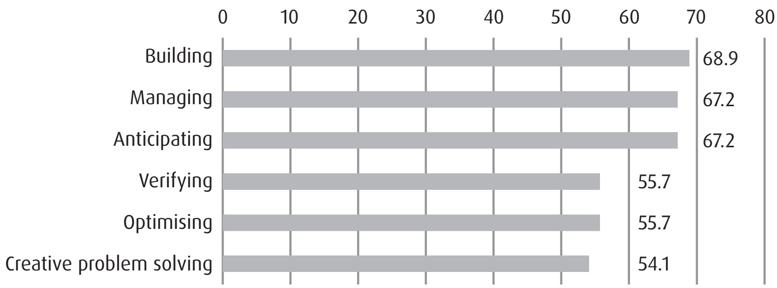
Retail companies must face up to a complete refurbishing of the work model in retail trade by focusing on the areas where data analysis and technology benefit both sides, ensuring customer satisfaction as well as business gains. To prepare retail companies for the upcoming change, attention needs to be paid to the analysis of the personal data related to employee skills and competencies. It will allow to better identify the existing gaps and prepare employees for the challenges of the future.

In the first months of 2022, an important factor for retail trade development was enabling large groups of Ukrainian citizens flowing into Poland and other CEE countries to learn the local language quickly, so that they may become valuable job candidates in the countries to which they arrived while fleeing the war.

It should be assumed that changes at the level of technology and customer preferences are happening so fast that the development of skills of retail employees is not catching up with the evolution of opportunities needed for retailers to defend their market shares and achieve growth. It is estimated that the number of hours spent performing physical and manual jobs in retail trade will shrink from 24% (2016) to 18% (2030), while the number of hours needed to carry out tasks requiring interpersonal and technological skills will rise. Retail companies which want to bridge the gaps by hiring new people will soon realise that some competence profiles will become increasingly scarce [Rushe, 2019].

The most vital competencies expected of retail trade employees today are: effective communication, ability to take care of customer needs, technological savviness, problem solving, effective teamwork and interpersonal competencies. Faced with the pandemic, many companies focused on adaptive activities in terms of fulfilling sanitary and operational requirements to ensure access to their trade offer, forgetting at the same time that it was necessary to support and develop their employees' skills.

Figure 2. Key competencies of retail sector employees (%)



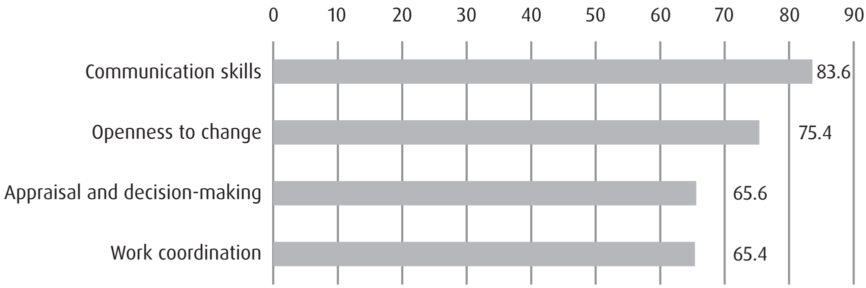
Source: self-reported data.

Key elements in building a foundation for versatile employee competencies are: employing flexible forms of education, skill development and practical vocational training which are the sources of competitive advantage as hard-to-copy individual competencies. Developing employee competencies and skills should be perceived as an investment in human resources and social capital, not merely as an operational cost.

Changes happening in the retail sector encourage companies to build a competitive advantage by tapping into relevant employee competencies, which will help generate market value. Representatives of the companies participating in the study indicated the most vital competencies to be building relations with customers, managing the sales process and anticipating customer needs (Figure 2)[2].

The most important competencies for the retail sector are: communication skills (83.5% answers) and readiness for change (75.4%). The other vital skills are the ability to make the right judgements and decisions (65.6%) and work coordination (65.5%) (Figure 3).

Figure 3. demand for employee competencies in retail sector (%)



Source: self-reported data.

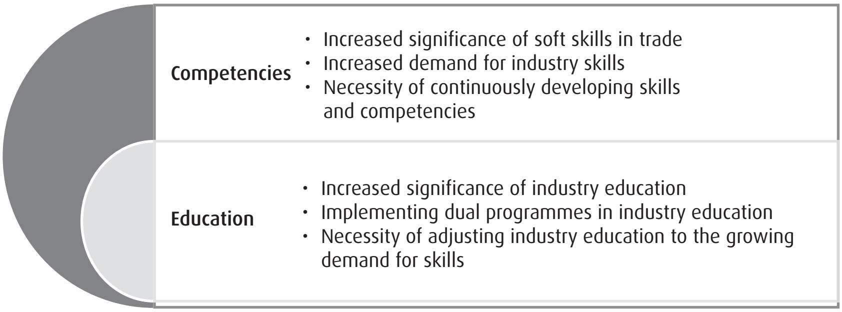
A significant factor of trade development in Poland is also an ability to identify the competence gap, including its scope and particular problem areas. Empirical studies' findings indicate that one of the key problems is the shortage of individuals with no proper industry education among store employees (65.6%), as well as at the managerial level (60.6%). The other issues included higher demand for employees with analytical (37.7%) and digital (34.4%) skills.

2 Own research conducted on the target group of 115 companies in the period from October to November 2021. Short characteristic of the research sample: dominance of companies with Polish capital – 80% of the studied companies; large companies accounted for 43% of the entities participating in the study, medium-sized and small – 26% each, and micro businesses – amounted to 5%. In terms of how long they operated on the market, most companies have been operating for more than 20 years – 52%, 39% have been on the market for 10–20 years, and 9% were the companies with operation time shorter than 10 years.

To study competence gaps and demand for skills in the retail sector it was also necessary to diagnose the barriers to processes involved in raising the competencies of retail employees. The most frequently indicated obstacle is the lack of independence among employees (62.3%) and shortcomings in the vocational education (45.9%).

Following the conducted studies and analyses, important areas for improvement in the retail sector were identified which comprise changes in the desired employee competencies as well as in vocational training (Figure 4).

Figure 4. Key directions of change in employee competencies and education in the retail sector



Source: self-reported data.

In the context of the above findings a question emerges about how technology can be employed for mitigating the shortage of qualified personnel. First, an effective recruitment process needs to be ensured. By engaging technology in the recruitment process companies can circulate training materials, provide access to the required documents and business communication channels during the employee's first days in the company. Streamlining this process can take some weight off the managers' shoulders, thanks to which they will be able to focus on building better relations with employees, at the same time providing the newly hired employees with access to vital knowledge helpful in the onboarding process and integration with the company. As a result, new employees' induction process can become more coherent, irrelevant of time and place, and can allow the staff to fully engage with their responsibilities from the very start.

Effective planning when staff shortages occur is also vital. It is virtually impossible to ensure the continuity of business operations without efficient systems of planning human resources and in-company communications. This problem can be tackled by using applications which allow the staff to adjust their availability, harmonise changes and swap duties with other employees whenever necessary without having to involve the management.

Another vital element of modern company operations is increasing employee satisfaction and work engagement. Technology can offer a digital, personalised communication centre which will help them stay up-to-date with important information, training courses or health check-ups. These channels can also streamline the process of communication in an organisation as well as improve cooperation between employees and their managers, facilitating feedback and boosting employee engagement in company goals.

Knowledge management throughout the organisation as well as developing staff competencies by training and professional growth is equally crucial. It is highly difficult to organise this area, particularly in a dynamic environment of the retail trade, but it certainly cannot be dispensed with in an expanding company. Technology and a digital space for education give employees the access to the training courses they want and need, as well as opportunities of gaining new knowledge and skills.

Importantly, the roles performed by employees in the points of sale should be analysed and defined in terms of the value they contribute to the organisation, only then relevant employee competencies can be effectively developed by entrepreneurs running such stores. It is usually the “front line” positions that generate more gains than others. High value tasks are performed by team leaders, sales employees who work with customers and experts who move between departments in order to disseminate knowledge and train the staff to use new tools.

In most cases, industry representatives claim there exists a discrepancy between the skills they need for the organisation to succeed and the potential they have at their disposal in terms of skills and abilities. Market leaders solve these problems by making informed decisions about how to bridge the competence gap and by applying cutting-edge analytics in the following three areas:

- maximising value by using the existing staff potential;
- acquiring the skills and competencies available on the market by refining recruitment strategies with the use of Big Data;
- hiring casual workers (temping) in some areas to ensure operations continuity.

In the first case it is about maximising value based on the competencies and knowledge of the existing employees. Tapping into the available technologies will allow many retailers to achieve maximum efficiency without the need to change the present model of work. For example, analytics can help facilitate the process of new employee onboarding, identify individuals achieving the best results in their role, help staff develop through electronic coaching as well as boost the retention of high-achieving employees through investments aimed at developing competencies and performance-related pay [Beyond Hiring, 2020]. As the roles evolve, investing in new skills becomes vital, particularly in the fields which will drive future growth, such as interpersonal and technological skills.

The store of the future will not merely be a central point of the technologically amplified customer experience, but also a hub of data collection and making business decisions based on the available analytical solutions. New technologies include both intelligent price tags and targeted in-store sales promotions displayed on smart shopping carts or sent to smartphones of the registered customers. Consequently, qualified workforce is a key prerequisite for maximising the value generated by such innovations. Raising qualifications does not always come as a formalised training course. For example, targeted intervention activities based on behavioural science may release creativity, drive innovation and boost employee efficiency. The use of technology in retail involves various solutions: for example sales instructions can be sent to the mobile devices of the staff currently present in the store, depending on their profile and store dynamics, and the cash register may display prompts as the customer is being attended to, using scripts promoting high levels of customer service satisfaction. These are some of the examples of activities leading retailers use to stimulate employee behaviour and increase overall retail efficiency [DiLeonardo, Mendelsohn, Selvam, Wood, 2020].

Another important aspect is cultivating a pro-active approach to recruitment. Not all staff competence shortcomings may be compensated for with coaching and training. Due to the fact that the existing roles continue to evolve and the new ones emerge, retailers must also adjust their strategies in fighting for talent. Data analysis may help retailers determine what skills they actually need, which will increase their chances for hiring the best candidates.

The last of the previously mentioned areas is the use of flexible forms hiring. Retailers who wish to hire particular specialists often see that many potentially suitable candidates with the relevant skills are more readily hired by technological firms or start-ups than traditional retail outlets. Good news is, not all competencies are permanently required. To meet the short-term demand for specific skills, retailers may use various forms of flexible employment.

Competencies of the future in retail

Among the key competencies of the future are the skills related to the process of retail digitalisation. Other relevant areas are also anticipating consumer needs and personalising sales offers. The knowledge of social media – as a way of creating consumer habits – and offer optimisation are also vital as they allow to generate new touchpoints and service delivery outlets. Other key skills will be understanding consumer attitudes, especially when consumers are becoming prosumers – sustainable consumers, knowledge of professional communication tools as well as competencies necessary for building the conception of the sharing economy and sustainable growth.

Also the aspects of creativity, implementing new solutions and anticipating future changes will be of significance in helping to adjust corporate processes. It will also be necessary to manage teams efficiently and build the organisational culture of engagement. On the other hand, high volatility of the business environment in which retail companies are operating nowadays requires a set of extremely useful competencies from the area of crisis management – the skills of agile responding to change, organised decision-making as well as harmonised and assertive introduction of new procedures and processes.

When representatives of the retail sector take steps towards closing competence gaps, the model of work in this industry will be turned around completely. It will require a focus on these areas where analytics and technology offer mutual benefits, ensuring both customer satisfaction and business success. Apart from using modern technologies, market leaders apply design thinking to rediscover retail trade by using top-notch solutions. Design thinking is a method which redefines the traditional approach to product development and establishing processes starting from an unsatisfied customer need, unresolved issue or pattern of action.

Trends affecting the industry in Central and Eastern Europe

Technological changes and market conditions lead to the emergence of the third generation retail focused on fast and cost-effective delivery of goods. This trend is present both with ultrafast and hyperlocal delivery companies which use the available technological tools, and with established retailers who want to expand and refine customer buying experience with the omnichannel approach.

These are some of the key trends which will shape the future of retail trade:

- supply chain diversification and production localisation which will mitigate risks and build resilience to unpredictable occurrences; this trend will be also encouraged by the war in Ukraine, particularly by its effects on global prices of food and the resulting changes in supply chains;
- production digitalisation and automation and a rise in e-commerce, also on the B2B market;
- sustainable growth – more focus on social and environmental concerns, also in the perspective of global supply chains;

- new challenges for companies, problems such as rising production costs, price pressure, the risk of labour force fluctuations, shrinking productivity;
- revamp of effective supply sources and development of traditional products, also local brands;
- problems with the availability of employees as a result of restricted mobility; possible changes due to increasing migration caused by the war; on one hand it means an abrupt influx of millions of new consumers who are also job seekers and need to very quickly acquire specific competencies such as speaking the local language, on the other, these numerous consumer groups appearing on the market in a short time period present a serious challenge to the supply chain;
- retail digitalisation which will give a wide consumer group access to e-commerce platforms, also between countries.

Consumers thinking in new ways

Throughout the last decade we have seen the process of consumers increasingly seeking more convenience and the use of technologies becoming an inherent element of the buying experience. Increased technology dependence became even more apparent during the COVID-19 pandemic when retailers and companies were striving to stay in touch with customers.

Consequences of the COVID-19 pandemic have certainly accelerated the digital transformation in the retail sector. Apart from increasing the capacity in online channels, retailers have invested also in the technology applied in bricks-and-mortar stores in order to create contactless experiences in retail.

Currently, a key motivation for visiting a physical store when purchasing material goods is wanting to see or try on the real product. It is even more important when buying more personal categories such as clothing and beauty or the so called shopping goods like furniture. It does not come as a surprise that experiences of using the technology which reduces physical contact have recorded the highest increase in the past two years. These include, among others, facial recognition, virtual trying-on or contactless checkouts, the elements which offer added value to shoppers.

One of the key trends in the retail landscape recently has been the changes in the perception of customer loyalty. Consumers have been more technologically savvy and, as a result, have higher expectations. Companies have to respond with predictive personalisation and employ aggregate data analysis. Speaking of loyalty, it should be noted that consumers in Poland do not form attachment to any particular brands or products – they usually chase bargains. Lack of loyalty creates a strong pressure on pricing and product range policies, it also means that customers have high expectations about the access to additional services and promotional offers. Advanced solutions are employed for that purpose, which requires access to the expanded infrastructure of the organisations managing retail chains.

Customers expect immediate delivery as the demand for faster and more convenient ways of shopping is on the rise. In many big cities offers of ultrafast delivery keep appearing. According to consumers, companies should undertake environmental initiatives and be environmentally conscious when building their product ranges.

Summary

Changes happening in the society, among consumers and in the entire retail sector determine its present character. This transformation involves a number of clashing factors which will determine where retailers will be seeking innovation and how the retail sector will evolve in the future.

The successful companies will be those that are able to understand their consumers and are continuously on the lookout for various sources of inspiration coming from other industries and categories, thus discovering future development paths. The key to meeting customer needs is to understand their actual preferences. The following are some of the challenges facing the retail sector amidst the changing market conditions:

- catching up with the pace of technological change taking place in Poland and around the world while simultaneously optimising investments;
- continuously meeting customer needs and new preferences – e-commerce, fast delivery, price sensitivity, quality of customer service;
- mastering the supply chain and increasing its efficiency, also in terms of availability and costs;
- conducting horizontal and vertical integration – employing franchising as an effective distribution model;
- demographic trends observed in Poland and worldwide – the ageing populations;
- acquiring qualified employees with specific and relevant retail competencies.

The COVID-19 pandemic has affected the circumstances in which both the retailers and consumers operate, which had a direct effect on the evaluation of short and long term retail trends in the CEE region. In a strategic perspective, industry representatives should take measures aimed at building resilience and flexibility to the changing market conditions as well as enhance the processes of the digital transformation. The solution which should be in the centre of attention is a customer-centric approach combined with sensitivity to environmental and social issues.

To recap, in the face of the transformation under way, it is necessary to efficiently implement a modern model of retail operations which will allow to satisfy demand on one hand, and on the other, deliver on the revenue and profit targets. It is paramount to refine the processes of serving the "new customer" and improve the efficiency of the supply chains, which requires a digital transformation implemented in the highest possible number of business processes.

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SYSTEMS OF SUPPORT FOR START-UPS IN THE COUNTRIES OF CENTRAL AND EASTERN EUROPE

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Abstract

The study fills the theoretical knowledge gap about the support provided to start-ups by the countries of Central and Eastern Europe. It provides an in-depth description of the development of factors comprising start-up support systems and identifies the region's leaders. The study continues and deepens work carried out by the research team in 2019, 2020 and 2021, and is based on data from the last available reporting period of 2021. To achieve the research goal, numerous methods and techniques were used, including reference literature analysis, secondary data and documents analysis, electronic review of official internet websites of enterprises and institutions, statistical analysis and a panel of experts carried out with a Delphi method and binary comparison. The research found that Estonia and Lithuania are the leading providers of start-up support systems in CEE, followed by Czech Republic, Poland, Slovenia and Latvia, next in the ranking of their systems maturity. The research results carry several practical implications in terms of start-up support systems evolution, and transfer of institutional best practices that impact the success of CEE countries. The research was an attempt to fill the theoretical gap in a synthesised description of start-up support systems in CEE countries, based on data from the latest available reporting periods.

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Start-up support systems, defined as compounds of interrelated factors, are a subject of research and various rankings, some with international coverage. This study covers also state public policies aimed at entrepreneurship and innovation, as well as systems of factors supporting start-ups at all development stages.

The region of Central and Eastern Europe (CEE) was defined by the Organisation for Economic Cooperation and Development [OECD, 2020] as a group of 12 countries (Albania, Bulgaria, Croatia, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia, Slovenia, Hungary) For the sake of this study, the group includes also Ukraine, and, under the common name of CEE used further in the article, it is subject to an in-depth and systemic analysis of start-up support systems. The authors of this study have identified a research gap, especially in respect of the number of publications comprehensively covering the geographical region defined in this way. International research on start-up support systems is diversified both in respect of the analysed factors and countries covered by analyses. A list presenting the current state of research works and a proposal of extending it with additional elements is presented in table 1.

Therefore, the main objective of this study is to fill the theoretical knowledge gap by answering the question on how do CEE countries support their start-ups. The specific objectives are to establish the development stage at which particular factors comprising start-up support systems in CEE currently are, and to indicate which of the CEE countries reach the highest development level in creating start-up support systems.

Table 1. Review of selected factors of start-up support systems and geographical scope of studies

Institution, study title, year of publication	Factors of start-up support systems selected for research	Does the study cover all the 12 CEE countries and Ukraine?
Startup Genome, *Global Startup Ecosystem Report*, 2021	Local networks, global networks	No (5 of 13)
European Startups, *Supercharging the European Tech Ecosystem*, 2021	VC financing, academic entrepreneurship, government support programmes	Cross-section, no CEE context
European Startups, *The Past, Present and Future of European Tech*, 2021	VC financing, academic entrepreneurship, government support programmes	Cross-section, CEE analysed as a whole
European Startup Network, *Startup Recommendations for the Post-COVID-19 Economic Recovery*, 2020	Recommendations for start-ups and EU Member States in different fields of activity (e.g. financing, talent acquisition, legal solutions)	Cross-section, no CEE context
European Commission, *Science, Research, and Innovation Performance of the EU*, 2020	Demographic potential, economy productivity, economic growth, institutions	No (12 of 13), without Ukraine
World Intellectual Property Organization, *Global Innovation Index*, 2021	Institutions (policy, regulations, business environment), human capital (including education), infrastructure (IT), market, innovation network, knowledge creation, knowledge absorption, knowledge diffusion	Yes (13 of 13)
European Commission, *European Innovation Scoreboard*, 2021	Human resources, attractiveness of research and development system, intangible assets, business environment, financing business activities, private investments	Yes (13 of 13)
World Economic Forum, *The Global Competitiveness Report*, 2020	Public policies, institutions, competitiveness of national economy, financing of business activities, labour market, dynamics of economic phenomena, in this edition also economic recovery after the crisis	Yes (13 of 13)

Source: self-reported data based on the data of European Startup Network [2020b]; European Startups [2021a, 2021b]; European Commission [2020, 2021]; Startup Genome [2021]; WIPO [2021]; WEF [2020].

First, research methodology is described, along with tools and techniques used to achieve the specific objectives described above, as well as time and geographical scope of the research. In the following sections the authors present particular factors of start-up support systems in CEE countries. Then the empirical part of the study evaluates and rates support systems in the Central and Eastern Europe and in Ukraine.

The summary provides conclusions and recommendations referring to the start-up support theory and economic practice.

The key context of this year's research is sustainable economic development. This study presents case studies featuring start-ups carrying out tasks provided for by *2030 Agenda for Sustainable Development* [Ministry of Development, 2015].

Methodology of research on start-up support systems in CEE countries

In recent years Central and Eastern European countries have undertaken multiple measures to improve their start-up support systems. They were supposed to make the systems more entrepreneur- and investor-friendly and to ensure them robust growth, so that start-ups supported by them can expand internationally and be successful on a global scale.

In order to systematize the way the research on start-up support systems is done, the research team decided to analyse, as a part of a panel of experts consisting of entrepreneurship and innovation researchers, factors that comprise start-up support systems typical for CEE countries. The key elements are:

- social and economic development;
- tax system;
- intellectual property protection;
- academic entrepreneurship;
- government agencies;
- start-up accelerators;
- regulatory sandboxes;
- clusters and network organisations uniting start-ups;
- venture capital funds (VC);
- success of start-ups and their significance from the perspective of their visibility and recognisability for the start-up support system stakeholders.

In order to establish the development stage of individual factors comprising start-up support systems in CEE, reference literature published by international organisations was reviewed. Additionally, the authors analysed source documents and data, including legal acts of individual CEE countries, reviewed information available on official websites of institutions related to the research area, analysed data in the form of time series and conducted statistical analyses.

To identify CEE countries most advanced in terms of building start-up support systems, the research team conducted a panel of experts using the Delphi method. First, binary comparison was applied to establish weights of the 10 factors comprising state start-up support systems (with total value of weights being 100%). Next, the research experts responsible for studies dedicated to individual factors of start-up support system rated them from 1 (very low development rate) to 5 (very high development rate) for each analysed country. The results of the panel of experts conducted using the Delphi method are presented in the form of a ranking, showing the leaders of start-up support systems in CEE. Additionally, the case study method was applied for the factor reflecting start-up success, which allowed to present descriptive aspects and aspects explaining the success of several businesses from CEE. The intention of the research team was to use the most recent available sources of data enabling international comparison of factors of start-up support system operating in CEE on an international scale, also on the basis of data from 2021. As mentioned before, geographically the research covers countries from the CEE region (Albania, Bulgaria, Croatia, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovakia, Slovenia and Hungary), extended by Ukraine in this year's edition of the report. The research was conducted from 26 February to 30 April 2022.

Factors of start-up support systems in CEE countries

Further sections of the article present factors comprising the analysed start-up support system in CEE countries, such as social and economic development, tax system, intellectual property protection, academic entrepreneurship, government agencies, start-up accelerators, regulatory sandboxes, clusters, VC funds and start-up success, perceived also as a factor affecting the start-up support system in a given country. The next part of the study describes ranks assigned to individual solutions, juxtaposed with all the analysed factors, as well as both detailed and general evaluations of countries.

Social and economic development of CEE countries

The countries of CEE are important partners in the European integration process, but unfortunately their economic development in many aspects is poorer than that of the other European Union members. The differences in the rate of regional development were analysed using Eurostat data. Changes in GDP *per capita* that have been observed in Member States since 2009 in relation to the EU average are presented in table 2.

Analysis of average pace of changes in these rates shows that the highest average growth rate in the examined period was observed Lithuania (annual average +3.9%) and Romania (+3.0%). Table 3 presents detailed results.

Table 2. GDP *per capita* of CEE countries compared to the EU average in 2009–2020

PKB *per capita* (PPS, 2020=100)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Albania	28	29	30	30	29	30	30	30	30	30	30	30
Bulgaria	44	45	46	47	46	47	48	49	50	52	53	55
Croatia	63	61	61	61	61	60	61	62	64	65	66	64
Czech Republic	87	84	84	84	85	88	89	89	91	92	93	93
Estonia	64	66	71	74	76	78	76	77	79	81	82	84
Lithuania	57	61	67	71	74	76	75	76	79	81	84	87
Latvia	53	54	56	61	63	64	65	66	67	69	69	70
Poland	60	63	66	67	67	68	69	69	70	71	73	76
Romania	52	52	52	54	55	56	56	60	64	66	69	72
Slovakia	72	76	76	77	77	78	78	73	70	70	69	70
Slovenia	86	85	84	83	83	83	83	84	86	87	88	89
Hungary	65	66	67	67	68	69	70	69	69	71	73	74

Source: own work on the basis of data of Eurostat.

Table 3. Average growth rate of GDP *per capita* of CEE countries, compared to the EU rate in 2009–2020

Country	AGR*	Country	AGR*
Albania	100.63	Latvia	102.56
Bulgaria	102.05	Poland	102.17
Croatia	100.14	Romania	103.00
Czech Republic	100.61	Slovakia	99.74
Estonia	102.50	Slovenia	100.31
Lithuania	103.92	Hungary	101.19

* Average growth rate calculated as a geometric mean of chain base index numbers.
Source: self-reported data based on data of Eurostat.

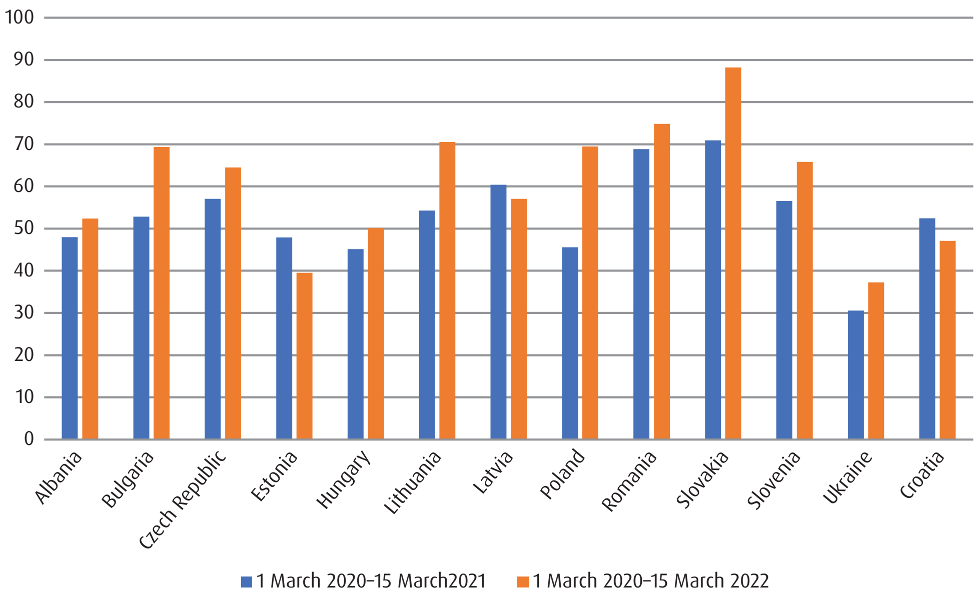
Most regions (NUTS2) of the analysed countries will be subject to advantageous financing conditions under cohesion funds in the 2021–2027 financial perspective. This will allow to maintain advantageous conditions of start-up development support funded from European funds.

As of the date of preparation of this report, it is very difficult to assess the general impact of the COVID-19 pandemic on the social and economic situation of the region, but analyses performed so far indicate sizeable changes in GDP. In the context of the start-ups development it is evident that the current situation has created unique development opportunities for certain fields of economy, at the same disrupting business models and consumer behaviour observed so far. Protection schemes launched in many countries, also in CEE countries, often even encourage entrepreneurs to initiate or try new business models.

Scale of economic intervention of the governments of individual CEE countries in connection with the pandemic

A project called *Oxford COVID-19 Government Response Tracker* (OxCGRT) has developed a set of 19 indicators of government measures in the areas comprised by our research, pertaining to, among others, restrictions imposed on business activity, economic support or adjustments in the healthcare system. This study comprises factors of economic support provided by governments of individual states, in particular:
1) income support (including money for businesses, if they are clearly connected with payroll or remunerations);
2) credit holiday and tax allowances for households;
3) fiscal policy (tax allowances, government spending);
4) financial support for other states.

Figure 1. Indicator of economic support provided by state governments due to the COVID-19 pandemic*



* Average value of the indicator referring to data from the period 1 March 2020–15 March 2021 and 1 March 2020–15 March 2022.

Source: self-reported data based on Blavatnik School of Government [2022].

In the previous examined period high and moderately high rate of interventionism was observed in most CEE countries, except Ukraine. Later in 2021 and in 2022 this rate was increasing, which reflects intensified measures of the state governments (with the exception of Latvia and Estonia, where from 16 March 2021 to 15 March 2022 the rate was lower than in the previous period). The biggest growth of the rate was recorded in Poland (52% increase), Bulgaria (31%) and Lithuania (30%). The highest value of the rate for the whole period was observed in Slovakia (88.21), Romania (74.85) and Poland (69.46), while the lowest rate was again in Ukraine (=37.25) and Estonia (39.50). Figure 1 presents detailed data.

Fiscal system and start-up support systems in CEE

CEE countries attach a lot of importance to appropriate legal and fiscal conditions, to the development of local and regional ecosystems of entrepreneurship and innovation, and to support for start-ups. Fiscal systems in all the CEE countries comprise multiple tax incentives to make new investments, such as establishing start-ups. Most popular solutions in place in the region are tax credit, corporate tax exemptions or favourable social insurance contributions. Moreover, all CEE countries also provide tax incentives for research and development (R&D) that also contribute to the creation of new start-ups, such as the possibility to deduct part of costs of revenue incurred for R&D from tax base. Unfortunately, only Latvia has introduced comprehensive fiscal systems dedicated to start-ups. It covers a fixed low rate of social security contribution for employees, irrespective of their salary, when at least 2 people are employed, or zero-rate corporate income tax when the profit is reinvested in the business, or optional zero-rate personal income tax for start-up employees. Sadly, during the COVID-19 pandemic few CEE countries (Czech Republic, Estonia, Romania or Bulgaria) had a stable fiscal system, which made it possible to respond to challenges induced by the epidemic. Most CEE countries (e.g. Slovenia, Poland or Hungary) in that time introduced many amendments in their fiscal systems, such as exit tax, digital tax or retail sales tax. What is more, these states run very unstable fiscal policy in response to the COVID-19 pandemic.

Table 4. Changes in fiscal systems of CEE countries in the time of the COVID-19 pandemic and support for start-ups

Country	Fiscal system dedicated to start-ups	Tax incentives for investments	Tax incentives for R&D	Number of fiscal policies connected with COVID-19 pandemic	Amendments of tax rates	Amendments of tax base
Albania	No	Yes	Yes	7	5 neutral + 1 reduction	5 neutral
Bulgaria	No	Yes	Yes	6	3 neutral + 3 reductions	6 neutral
Croatia	No	Yes	Yes	16	3 reductions + 5 neutral	8 neutral + 1 reduction
Czech Republic	No	Yes	Yes	13	6 neutral + 2 reductions + 1 rise	3 reductions + 6 neutral
Estonia	No	Yes	Yes	14	6 neutral + 4 reductions + + 4 rises	6 neutral + 4 reductions + + 4 rises
Lithuania	No	Yes	Yes	13	11 neutral + 2 reductions	3 reductions + 2 rises + + 8 neutral
Latvia	Yes	Yes	Yes	24	10 neutral + 4 reductions + + 9 rises	16 neutral + 7 reductions
Poland	No	Yes	Yes	55	34 neutral + 14 reductions + + 1 new tax	39 neutral + 1 new tax + 8 reductions
Romania	No	Yes	Yes	1	comprehensive tax reductions	comprehensive tax reductions
Slovakia	No	Yes	Yes	12	8 neutral + 1 rise + 3 reductions	4 rises+ 4 reductions + + 4 neutral
Slovenia	No	Yes	Yes	26	1 rise + 1 reduction + 24 neutral	4 reductions + 20 neutral
Ukraine	No	Yes	Yes	no data is available	no data is available	no data is available
Hungary	No	Yes	Yes	32	14 reductions + 9 neutral + 3 rises + 2 new taxes	12 reductions + + 10 neutral + 2 new tax + + 4 rises

Source: own work on the basis of data of Eurostat [2022] and OECD [2021].

Case study

Slovenia: Juicy Marbles

A Slovenian start-up located in Ljubljana, which was the first in the world to create an alternative type of steak. Tilen Travnik (food technologist), Luka Sincek (microbiologist) and Maj Hrovat (biotechnologist) set up the company in 2020, based on their previous experience from work in the food and biotechnology industry. In that same year the start-up team was joined by more people, including Vladimir Mickovic (a chef). Juicy Marbles team, consisting of both vegans and meat eaters, focuses on creating balanced products, using marbling technology.

Using a device called Meat-o-Matic Reverse Grinder 9000 (patent pending), the start-up can imitate the texture and marbling of meat by layering fibres made from exclusively natural components, such as soy protein. The biggest challenge in creating the soy steak is to achieve properly even and muscle-like structure of fat – the aforementioned marbling. The realistic structure of the alternative, plant-based steak is very important, since vegan customers are increasingly demanding and growing in number. The marbling technology makes it possible to recreate fillet mignon, which in the future, thanks to Juicy Marbles, will be more affordable, and thus more available. Apart from the looks and texture, which mimics a real meat steak. the success of fillet mignon relies also on its taste, which, as the start-up team claim, is as good as that of the real animal-based meat.

Currently Juicy Marbles team focus mostly on the production of the steak, and for now avoid introducing more production lines. The use of soy as the basic protein will definitely give the start-up more flexibility in developing other products in the future. For example, the team are already working on a prototype of a vegan tuna steak and are planning to include plant-based equivalents of seafood in their product range. According to the founders of Juicy Marbles, 97% of soy crops are now used to produce animal feed. Probably one-third of these crops would suffice if the soy was directly used in food products intended for humans.

Source: Buxton [2021], Biofuels Digest [2021], Horeca Trends [2021] and Kaja [2021].

Intellectual property protection in CEE countries

The COVID-19 pandemic, which affected CEE in 2020 and 2021, has not had a particularly adverse impact on the protection of intellectual property. From 2019 to 2020, CEE countries recorded aggregate 27% growth in the number of inventions filed under the European procedure, 11% growth in the number of filed EU industrial designs, and 3% growth in the number of filed EU trademark applications. From 2020 to 2021 the number of inventions filed under the European procedure grew by 0.16%, and the number of filed EU industrial design applications and EU trademark applications increased by 21% and 29%, respectively. The only category for which a 6% drop was recorded were trademark applications under national and international procedure. Let us note, however, that these changes referred to the years 2019–2020, which means that they were caused not so much by the pandemic, as by increasing popularity of EU applications in CEE countries.

In 2021, the region's leaders in terms of rate of growth of EU invention applications were, just as the year before, Lithuania (46%), Croatia (23%) and Estonia (21%), which filed 73, 27 and 69 applications, respectively. A decrease in the number of applications between 2021 and 2020 was recorded in 6 out of 12 CEE countries. The biggest drops were observed in: Romania (–44%), Slovenia (–30%) and Slovakia, with 30, 116 and 42 applications filed, respectively.

The biggest growth rate of EU industrial design applications could be observed in Croatia, Lithuania and Poland. In Croatia the number of applications increased by as much as 57%, which was equivalent to 99 new applications, in Lithuania – by 40% (184 applications) and in Poland – by 29% (5543 applications).

In terms of growth in EU trademark applications the leader was again Lithuania (62%), followed by Czech Republic and Slovakia (41% and 38%, respectively). The percentage growth translated into 1039 new applications Lithuania, 1980 in Czech Republic, and 681 in Slovakia. Only one country, Albania, saw a decline in the number of applications, for the second year in a row, by 21%, down to only 11 applications in 2021.

In absolute numbers the most inventions under the European procedure are submitted in the largest CEE countries: in Poland (539 applications and 240 patents granted), Czech Republic (203 applications and 133 patents granted) and Hungary (118 applications and 53 patents granted). It is also the case for European industrial designs and trademarks, only the place of Hungary in these two categories is taken by Bulgaria (industrial designs) and Romania (trademarks) (Table 5).

Table 5. Intellectual property protection in 12 countries of CEE (absolute numbers)

	Country	Losses caused by intellectual property right violations in 2020 (EUR million)	European patents (applications) in 2021	European patents (granted) in 2021	National and international industrial designs (applications) in 2020	National and international trademarks (applications) in 2020	EU industrial designs (applications) in 2021	EU trademarks (applications) in 2021
1	Bulgaria	377	40	23	199	4853	436	1195
2	Czech Republic	464	203	133	278	9131	809	1980
3	Estonia	66	69	12	85	2309	128	915
4	Lithuania	142	73	19	113	2189	184	1039
5	Latvia	105	22	18	143	3342	84	343
6	Poland	2038	539	240	1060	16,217	5543	6236
7	Romania	1040	30	12	307	10,772	343	1468
8	Slovenia*	126	116	79	110	2700	116	564
9	Slovakia	367	42	33	145	4032	226	681
10	Hungary	547	118	53	175	5165	143	917
11	Albania	–	–	–	169	3252	0	11
12	Croatia	232	27	7	278	2510	99	353

* For Slovenia the data on national and international trademark applications and industrial design applications cover the year 2019.

Source: self-reported data based on the data of EUIPO, WIPO and EPO.

Table 6. Intellectual property protection in 12 selected countries of CEE (*per capita* or per 1 million citizens)

	Country	Population (in millions)	Losses caused by intellectual property right violations per 1 citizen in 2020 (EUR)	Number of European patents (applications) per 1 million citizens in 2021	European patents (granted) per 1 million citizens in 2021	National and international industrial designs (applications) per 1 million citizens in 2020	National and international trademarks (applications) per 1 million citizens in 2020	EU industrial designs (applications) per 1 million citizens in 2021	EU trademarks (applications) per 1 million inhabitants 2021
1	Bulgaria	7.05	53.5	6	3	28	688	62	170
2	Czech Republic	10.61	43.7	19	13	26	861	76	187
3	Estonia	1.32	50.0	52	9	64	1749	138	693
4	Lithuania	2.81	50.5	26	7	40	779	65	370
5	Latvia	1.93	54.4	11	9	74	1732	44	178
6	Poland	37.98	53.7	14	6	28	427	146	164
7	Romania	19.53	53.3	2	1	16	552	18	75
8	Slovenia*	2.006	61.0	56	38	53	1307	56	273
9	Slovakia	5.44	67.5	8	6	27	741	42	125
10	Hungary	9.78	55.9	12	5	18	528	15	94
11	Albania	2.87	–	–	–	59	1133	0	4
12	Croatia	4.11	56.4	7	2	68	611	24	86

* For Slovenia the data on national and international trademark applications and industrial design applications cover the year 2019.

Source: self-reported data based on the data of EUIPO, WIPO and EPO.

For the sake of comparison, a more important parameter than the absolute number of applications is the number of applications per 1 million citizens (Table 6). The CEE leader in respect of patent application is in this case Slovenia (56 applications), before Estonia (52 applications) and Lithuania (26 applications). Poland, with its 14 applications per 1 million citizens, is on the 5th position of the ranking. It is also an unquestionable leader of the region in terms of the number of EU industrial design applications per 1 million citizens (146), outclassing last year's leader in this category, Estonia. The highest number of EU trademark applications per 1 million citizens was recorded also in Estonia (693 applications), which exceeded Lithuania (370) and Slovenia (273). Poland, with its 164 applications is in the middle of the ranking.

Academic entrepreneurship in CEE

Academic entrepreneurship is a mechanism of commercialisation of academic know-how, comprising education and promotion of entrepreneurial mindset, support for entities interested in running their own business, managing intellectual property born on universities, as well as universities acting in the capacity of investors involved in newly developed solutions [Matusiak, 2008]. It is an important element of a start-up support system, creating a bridge connecting the universities with practical applications of invented solutions.

Concurrence and mutual impact that major start-up ecosystems and academic centres have on one another is observed everywhere, also in CEE. The maturity of a start-up ecosystem may therefore be evaluated through the prism of academic entrepreneurship development on the leading universities. This section presents an evaluation of universities' involvement in the development of academic entrepreneurship in CEE, using a tool applied also in the previous editions of the report. Subsequent levels of the presented model indicate additional measures taken to support start-ups at individual stages of their growth. The analysis covered leading universities from CEE countries [QS, 2022]. The data come from website review and information provided by employees of the universities.

Table 7. Levels of universities' involvement in the development of academic entrepreneurship, with examples of measures

Level 0	**Level 1** (idea conceptualisation)	**Level 2** (idea specification)	**Level 3** (start-up phase)	**Level 4** (enterprise development)
No involvement in the development of academic entrepreneurship	education schemes/workshops, inspiration meetings, consultations, promotion of best projects (competitions)	pre-incubation, consultancy support, networking, co-working	incubator, accelerator, mentoring	Investment made by a special-purpose entity, spin-off, seed fund
	academic entrepreneurship carried out under university structure	autonomous university entity responsible for academic entrepreneurship or separate special-purpose entity		

Source: self-reported data.

Universities from the CEE region have been increasingly engaging in technology transfer and academic entrepreneurship. Scientific centres from Estonia, Czech Republic, Lithuania, Poland, Slovenia and Slovakia deserve recognition. Estonian universities offer particularly broad range of academic entrepreneurship services, as they carry out a comprehensive range of activities, including filling funding gaps at early stages of start-up development and ensuring access to various acceleration and incubation programmes. Ukraine also deserves attention, especially its start-up ecosystem created by the Kyiv Technical University, providing education programmes, start-up competition *Sikorsky Challenge*, access to tools and space of *Sikorsky Lab*, incubator and VC fund. Thanks to the broad range of available of solutions, the university has managed to build a brand that attracts national and foreign partners and innovators. The worst in dealing with implementation of academic entrepreneurship are Albanian universities, who do not offer any proposals for start-ups whatsoever. Initial stages of creating academic entrepreneurship can be observed in Romania and Croatia, where, compared to previous years, this kind of activity is being increasingly popular, especially in terms of building offer for start-ups.

Table 8. University involvement in the development of academic entrepreneurship (from 0 to 4)

Country	University	Rate of
Bulgaria	Sofia University "St. Kliment Ohridski"	3
Czech Republic	Masaryk University in Brno	3
	Palacký University Olomouc	4
	Czech Technical University in Prague	3
	Charles University in Prague	4
	Brno University of Technology	2
Estonia	Tallinn University	4
	Tallinn University of Technology	4
	University of Tartu	4
Lithuania	Vilnius University	4
	Kaunas University of Technology	3
	Vilnius Gediminas Technical University	2
	Klaipėda University	3
	Vytautas Magnus University	4
Latvia	University of Latvia	3
	Riga Technical University	2
	Riga Stradiņš University	3
Poland	Adam Mickiewicz University	3
	Warsaw University of Technology	4
	Jagiellonian University	4
	AGH University of Science and Technology in Krakow	4
	University of Warsaw	4
	Krakow University of Technology	4
	University of Wrocław	4

cont. table 8

Country	University	Rate of
Romania	Babeș-Bolyai University	1
	Politehnica University of Bucharest	1
	Alexandru Ioan Cuza University	2
	University of Bucharest	1
Slovakia	Pavol Jozef Šafárik University in Košice	3
	Slovak University of Technology in Bratislava	3
	Kaunas University of Technology	4
	Comenius University in Bratislava	4
Hungary	University of Debrecen	3
	Eötvös Loránd University	2
	University of Szeged	2
	University of Pécs	2
Croatia	University of Split	2
	University of Rijeka	1
	University of Zagreb	2
Albania	University of Tirana	0
	Epoka University	0
Slovenia	University of Maribor	3
	University of Ljubljana	4
	University of Primorska	2
	University of Nova Gorica	3
Ukraine	Taras Shevchenko National University of Kyiv	1
	Vasily Karazin Kharkiv National University	0
	National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"	4

Source: self-reported data based on websites review and information provided by employees of the universities.

Development of academic entrepreneurship requires knowledge and competences, adequate financial outlays and suitable infrastructure. What is particularly important is also access to EU funds, which have helped universities in CEE to improve their infrastructure and to develop competences necessary to support start-up growth. A challenge for entities in this region remains the issue of education and enhancing entrepreneurial mindset. The quality of entrepreneurship education at universities in CEE is still much poorer than in the Western Europe. Opinions reported to Global Entrepreneurship Monitor (GEM) by experts and businesspeople confirm this. According to them, of all the countries of the region only Lithuania and Estonia have in place entrepreneurship education systems providing quality of teaching above the average for the 50 analysed countries from all over the world [GEM, 2022]. It is also necessary to raise awareness of benefits from collaboration with academic organisations. Today only 9.5% European start-ups perceive universities as key collaboration partners [European Startup Network, 2020a]. This is the major barrier for initiating such relations, because when contacts with academia are established, start-ups with satisfaction highlight real and measurable support from universities in developing products, access to innovations, markets and clients.

Government agencies and start-up support systems in CEE countries

This section presents an evaluation of government agencies in CEE countries involved in start-ups support systems. For this purpose, the authors reviewed official websites of public institutions responsible for economic policy in individual states of the region. The analysis covers information on the measures exercised by public administration bodies engaged in start-up support systems, with their financial resources and substantive input. Their detailed list is presented in table 9.

Table 9. Measures implemented by government agencies as a part of start-up support systems in 2021

Areas of activities	Common measures
Financing	grants and competitions for financing enterprises establishment and development
	capital investments and loans provided directly by government agencies (e.g. state VC fund) to existing enterprises
	running a fund of funds or institution stimulating business angels and VC funds in the country by leveraging their capital
Stimulating start-up environment	educational and monitoring programmes that popularise entrepreneurial attitude and knowledge on establishing and running start-ups
	establishing and supporting incubators and accelerators
	running a dedicated website with comprehensive up-to-date information on start-up events, ecosystem participants, and statistical data
Internationalisation of national start-ups	supporting contacts of domestic start-ups at the initial stage with international partners, (e.g. through foreign visits, financing participation in start-up competitions, incubation and acceleration programmes)
	programmes supporting scaling start-ups internationally (e.g. loan guarantees, promotion support)
Attracting foreign start-ups	administrative simplifications for foreign start-up founders (Start-up Visa)
	administrative simplifications for employing foreign experts by start-ups (Start-up Employee Visa)
	website with information for foreign start-up founders considering relocation to a given country

Source: self-reported data based on the review of official websites of government agencies of CEE countries (12–19 April 2022).

Review of the collected information made it possible to evaluate the engagement of government agencies in CEE countries in the development of start-up ecosystems, broken down by identified areas of support. Table 10 presents detailed results.

Table 10. Evaluation of engagement* of government agencies in start-up support systems identified in 2021

	Areas of activities				Average score
	financial support	stimulating start-up environment	internationalisation of national start-ups	attracting foreign start-ups	
Albania	1	1	1	1	**1.00**
Bulgaria	2	1	1	1	**1.25**
Croatia	1	1	1	1	**1.00**
Czech Republic	3	5	4	2	**3.50**
Estonia	4	5	2	5	**4.00**
Lithuania	4	5	2	5	**4.00**
Latvia	3	5	2	5	**3.75**
Poland	5	5	4	2	**4.00**
Romania	1	1	1	1	**1.00**
Slovakia	2	1	1	1	**1.25**
Slovenia	4	4	4	2	**3.50**
Ukraine	1	2	1	1	**1.25**
Hungary	4	1	1	1	**1.75**

* Score on 1–5 scale, where 1 means no activities in a given area, 5 means comprehensive and consistent approach to performance of tasks.

Source: self-reported data based on the review of official websites of government agencies of CEE countries (12–19 April 2022).

The most engaged in the development of start-up support systems were public institutions in Estonia, Lithuania, Poland, Latvia, and Slovenia (average score 3.5–4). In some countries activities of government agencies rated poorly (from 1 to 1.75 points). In the other countries the average score was usually not higher than 2.

An analysis of profiles of countries with the most engaged institutions may identify model measures of support for start-up ecosystems. For the Baltic states it is typical to focus on attracting initiatives and start-up founders from abroad and to ensure them access to extensive financial support system. The Czech Republic assigns rather limited resources to this kind of measures, compared to other leaders, although considerable activity of public institutions can be observed pertaining to substantive aspects of the ecosystem development, especially with regard to internationalisation. The example of Poland covers all the areas of activities, and Polish public institutions are the most involved in attracting foreign start-ups. A similar approach, albeit with less involvement, is observed for government bodies in Slovenia

Case study

Estonia: NutriLoop

Estonian start-up, having its head office in Tallinn, uses biowaste in the process of sustainable production of food. Founders of NutriLoop highlight enormous amounts of potentially valuable organic matter produced by municipalities across the world. Unfortunately, most of it is not recycled – it is dumped on landfills and in waste incineration plants, which exacerbates pollution and wastage of valuable resources.

The trademark of NutriLoop was registered by its founders in 2018. A year later (2019) NutriLoop won the main prize in one of the biggest European entrepreneurship competitions in the agri-food sector, ETI Food Innovation Prize, organised by ETI Food, the goal of which is to build a future sustainable system that makes healthy and balanced food. In 2020 NutriLoop began collaboration with the Estonian town Keila, seeking possibilities to apply innovative and valuable model of circular waste management. In the course of works carried out in Keila the start-up found that the best solution is to create a community where biowaste is locally valorized, which also benefits the local inhabitants. NutriLoop with the Estonian Crop Research Institute also participates in a 4-year international project SEA2LAND conducted under the "Horizon 2020" programme. NutriLoop aims to create and advanced fermentation solution to produce fertilizers by combining fish waste with other biowaste and to describe business models that could be replicated in regions similar to Estonia. In 2021 the start-up took part in a pilot project covering a marketplace Balti Jaam in Tallinn and Telliskivi Creative City, located in former Tallinn industrial complex, now holding galleries, small shops, restaurants and offices of other start-ups. Also in 2021 NutriLoop joined the programme Tehnopol's Startup Incubator, enabling work on projects that aim to make the world a better place, and once more it proved that its team is involved in the achievement of sustainability goals and care about local community. Another valuable initiative of the start-up was joining Accelerate Estonia – a programme which will make rich-in-nutrients biowaste transform from a waste management problem into a solution advantageous for growing crops. Currently NutriLoop works on a model of processing and using waste in various Estonian towns and on a prototype of its own plant.

Source: ETI Food [2022], EU-Startups [2022] and NutriLoop [2021, 2022].

Start-up accelerators and clusters in CEE countries

Western Europe is still much more successful than the Eastern Europe in attracting start-ups, due to well-developed infrastructure, advantageous for establishing new businesses. According to a ranking of countries published in *The Global Startup Ecosystem Index Report 2021* [Startup Genome, 2021], it can be observed that, sadly, not much has changed since 2020 and start-up ecosystem in CEE countries, in spite of certain potential and resources, such as high-skilled specialists, is not developing as dynamically as equivalent ecosystems in the Western Europe. It seems that this situation results mostly from historical conditions that have shaped the local people's attitude to entrepreneurship and running their own business. The poor education system plays a role here as well, since in this part of Europe it neither prepares, nor inclines people to make the effort of having their own company. A positive aspect is nevertheless steadily growing number of accelerators in almost all CEE countries. These entities expose the potential to fill the gap in practical knowledge generated by the education system, and, additionally, they provide access to financing, mentoring networks, and connect businesses with corporations that could potentially become partners and clients of promising start-ups participating in support programmes. A comparison of start-up accelerators in the region is presented in Table 11.

Table 11. Start-up accelerators in CEE countries according to StartupBlink

Country	Position in Global Startup Rankings			Number of accelerators according to StartupBlink			Best ranked accelerators by StartupBlink in 2020	Locations with the largest number of accelerators in 2020
	2019	2020	2021	2019	2020	2021		
Poland	20	27	30	10*	10*	10*	Climate-KIC Accelerator Programme, Founder Institute Warsaw, MIT Enterprise Forum CEE, Kogifi, Huge Thing	Warsaw, Krakow, Wrocław, Poznań, Gdańsk
Estonia	13	11	13	5	9	11	Startup Wise Guys, Superangel, Tartu Science Park, Storytek	Tallinn, Tartu
Romania	38	45	41	5	5	5	Spherik Accelerator, Alpha Hub, Techcelerator	Bucharest, Kluj-Napoca, Jassy, Timisoara
Hungary	39	37	49	4	8	7	CEU Innovations Lab, MKB Fintechlab, OXO Labs, Hiventures	Budapest, Debrecen, Szeged
Slovakia	49	51	56	3	3	3	Startup Centre at USP Technicom CEED Tech – Slovakia, Launcher	Bratislava, Košice
Czech Republic	22	26	32	3	6	5	Startup Yard, AI Startup Incubator, VSEM Accelerator	Prague, Brno, Ostrava, Plzeň
Ukraine	31	29	34	15	12	12	BERRY, FoodTech accelerator by LvBS, YEP!	Kyiv, Lviv, Odessa, Kharkiv
Bulgaria	35	32	35	2	6	6	Start It Smart, Eleven Accelerator Venture Fund, Climate-KIC Accelerator Bulgaria, LaunchHub Ventures	Sofia, Varna, Plovdiv
Lithuania	18	15	16	3	6	18	Hostinger, Tesonet, Baltic Sandbox, Kaunas STP, Startup It	Vilnius, Kaunas, Klaipėda
Slovenia	48	35	46	2	2	2	Hekovnik Startup School, ABC Accelerator	Ljubljana, Maribor
Croatia	50	39	37	–	–	–	–	–
Latvia	45	36	42	–	2	2	Startup Wise Guys, TechHub Riga	Riga
Albania	85	72	78	–	1	1	Oficina	Tirana

* The authors of this study consider that the number of accelerators in Poland given in the quoted StartupBlink report is underestimated. Reference literature lacks studies dedicated to detailed analysis of Polish accelerators. More research is therefore required in this field.

Source: self-reported data based on Startup Blink [2022a].

An analysis proves that in 2021 the number of accelerators did not change much in most CEE countries, compared to the year 2020. In Latvia, Ukraine, Slovakia, Slovenia, Bulgaria, Romania and Poland the number of accelerators remained the same. The country that deserves recognition is Lithuania, which tripled its number of accelerators – from 6 in 2020 to 18 in 2021. The birth of the first "unicorn" in Lithuania definitely made it a more attractive place on the start-up map. In Estonia two new accelerators were established in 2021, while Czech Republic and Hungary each had one accelerator less than the year before.

The development of clusters can also be an effective form of attracting new innovative solutions. Success of clusters is explained by their organic growth and building organisational structure based on trust. Clusters should be treated as ecosystems of related industries and competences characterised by a broad range of inter-industry relations [Delgado, Porter, Stern, 2013]. Because of definition differences, it is difficult to establish a specific number of clusters in each country. Table 12 presents the number of clusters in CEE countries in the years 2019–2021. The most clusters in the analysed period were found in Poland and Romania, just as in the previous years. The fewest clusters were in Albania. Data from the last three years prove that the number of clusters is steadily growing in most countries, namely in Poland, Bulgaria, Romania, Hungary, Latvia and Slovakia, as well as in Czech Republic, Croatia and Slovenia. Just as in 2020, Slovakia deserves recognition, since its number of clusters grows each year. The same number of clusters as in the previous year was found in Ukraine, Estonia and Albania. The only country where the number of clusters fell last year was Lithuania, which reported a drop from 28 to 27 clusters.

Table 12. Clusters in CEE countries

	Poland	Romania	Bulgaria	Lithuania	Hungary	Ukraine	Czech Republic	Croatia	Estonia	Latvia	Albania	Slovakia	Slovenia
2019	67	51	26	24	23	23	18	13	11	11	2	4	17
2020	71	52	26	28	25	14	20	14	14	13	2	15	17
2021	76	59	29	27	26	14	21	15	14	14	2	25	19

Source: self-reported data based on the data of European Cluster Collaboration Platform [2022].

Among all the CEE countries, Estonia is considered to have the best start-up ecosystem, which is on the 13th position in the world ranking made by StartupBlink [2022b]. Its ecosystem covers many entities supporting entrepreneurship, which provide high-quality services. This is remarkable, considering the population of this country, which is only 1.5 million. Lithuania was on the 16th position in the ranking, the second CEE country on the list. Although Lithuania fell by one position in the ranking (in 2020 it was fifteenth), it should be highlighted that *Vinted* was its first unicorn last year. Poland has been regularly falling in the ranking – in 2021 it was on the 30th position. Despite strong economy, talented software developers and various strategies of entrepreneurship support, the country is far from reaching the goals it has set and taking advantage of its innovation potential [Startup Genome, 2021].

Case study

Czech Republic: DOT Glasses

DOT Glasses is a Czech start-up seated in Prague, which helps people who need sunglasses, but cannot afford to buy them. The start-up makes inexpensive 3D-printed spectacles. DOT Glasses offers affordable, universal frames, suitable for people with eyesight problems, and the optical power of lenses may increase by 0.25 dioptres, if local infrastructure allows for keeping bigger volume of the product stocks. DOT eyeglasses eliminate only spherical vision impairments, and do not correct cylindrical eyesight defects, because this would require additional personalisation of lenses, which in turn would significantly push up the costs of logistics and production.

DOT Glasses products are offered in countries such as Afghanistan, Bangladesh, Ethiopia, Ghana, India, Nepal, United States, Nigeria, Peru, South Africa, Uganda, Kenya or Zambia. The glasses consist of six-part snap-together, adjustable frames, customised and selected on the place of vision test made with a DOT test kit.

Start-up began to develop in 2014, when its founders, including Philip Staehelin, current CEO, set the goal to find a solution that makes glasses accessible – even to people living in the most remote villages on Earth who could not afford to buy standard spectacles. In 2015 the team of DOT Glasses came up with a radically simplified lens concept, based on the idea that a small variance from perfect vision is absolutely liveable and does not affect day-to-day functioning, and even driving vehicles. In 2017 a subsidiary of Mercedes-Benz began collaboration with DOT Glasses start-up and brought to life the world's first mass-producible, adjustable, one-size-fits-all frames. Thus, it was possible to introduce inexpensive glasses on the market. In 2018 first 3D-printed prototypes were successfully tested in field trials in Angola. In 2019 DOT Glasses launched the business at full scale, starting mass production, adding vision kits and children's glasses to their product portfolio. From 2020 the company has been expanding to new geographies and partnering with new distributors to reach more and more people who struggle to see.

Source: DOT Glasses [2022], Prague Morning [2021] and Radio Prague International [2018].

The role of regulatory sandboxes as an element of innovation support in the CEE region

Regulatory sandbox is one of the most modern forms of institutional support for start-ups. It is especially useful in highly innovative, yet strictly regulated sectors. A regulatory sandbox allows to verify in reality whether a specific innovative business is viable. This happens under the supervision of market regulation institutions, in strictly defined time frame and field of a sector. A regulatory sandbox conduces to start-up development, because it

- fills the regulatory gap by implementing necessary legal solutions for business development of a sandbox user;
- eliminates the risk of nonconformity with the supervision authorities, since it is them who provide the sandbox;
- reduces the risk of adverse effect of a sandbox user's business on the external environment;
- ensures opportunity to gain and exchange experience and transparent communication between sandbox users and the regulatory body;
- shortens the time necessary to introduce innovative solutions on the market [Jenik, Lauer, 2017].

In 2021 CEE countries saw further development of regulatory sandboxes, especially in respect of solutions using blockchain technology. The first blockchain sandbox in Poland was launched in November 2020, and in 2021 start-ups, among others, from Spain, Finland and Israel that had applied to participate in the projects began testing their solutions on the platform. Also the National Bank of Lithuania launched its blockchain sandbox. The evidence of dynamic development of this solution is the call for tenders to facilitate and operate a pan-European blockchain sandbox, launched by the European Commission in March 2022 European Commission, 2022].

At the beginning of 2022 the first regulatory sandbox for fintech solutions started to operate in Slovakia. For several years such instruments have been available in Latvia and Hungary, while Estonia, Romania and Slovenia are preparing to start their first regulatory sandboxes.

Case study

Slovakia: SmartHead

SmartHead is a Slovak start-up located in Bratislava, offering digital B2B solution for optimisation of company efficiency by measuring and reporting on sustainability goals achievement, and their transparent communication to stakeholders. The solution is dedicated both to small and medium-sized enterprises and big companies. Through the SmartHead platform, companies have access to best practices of other companies pursuing sustainable development goals and expert knowledge on SDG and ESG. SmartHead was founded in 2016 and won the competition Chivas Venture for social entrepreneurs. It has also participated in an accelerator organised by Saïd Business School at the University of Oxford. In 2018 the CEO of SmartHead, Veri Osvald, was included in the Forbes ranking of Top 10 Women Startups in Slovakia, and was nominated for the EY award for the Entrepreneur of the Year.

Over the SmartHead platform companies can measure, report and communicate in a transparent way their attitude to sustainable development to their stakeholders (both internal and external ones, such as clients, employees, business partners and investors), and thus earn their loyalty. By transparent communication of their attitude to sustainable development, employers boost their attractiveness during the employment process, mostly of all for the millennials and generation Z. When SDG are taken into account in key enterprise management decision-making, an organisation, through their profile, has in one place access to data pertaining to sustainability, and therefore to various proposals of actions and their impact, reports, certificates and press.

Over the last years SmartHead platform was joined by such international corporations as Dell Technologies, Tesco, Citi, IBM, Oriflame, EY, Accace, HB Reavis or McDonald's. They communicate their sustainability-related measures through the platform.

Source: SNEU [2022] and SmartHead [2022].

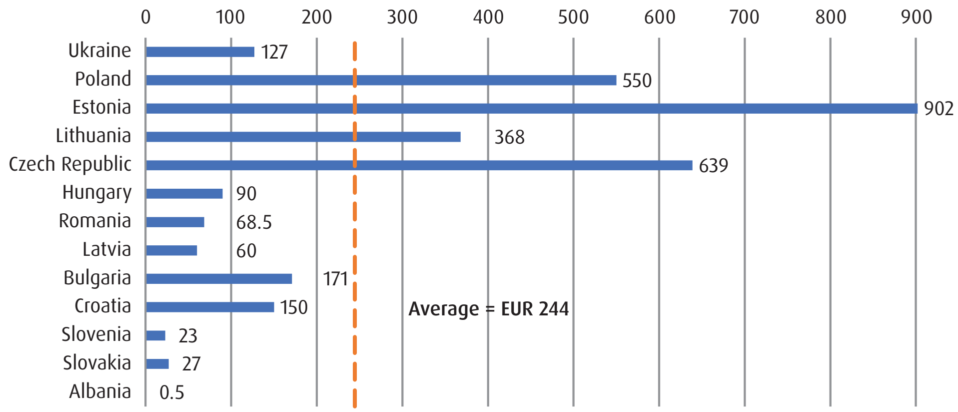
Activities of VC funds in CEE countries and support for start-ups

This section describes the activities of VC funds in CEE in 2021. Data used in the research were obtained from the digital investment platform Dealroom, founded in 2013 and having its place of business in Amsterdam. The authors have initiated cooperation with the platform in previous years. As of the date of the research (24 February 2022), Dealroom has aggregated data from 2 215 455 tech-enterprises (start-ups); 131 295 investors, including VC funds; 126 453 corporate partners, and results of 521 695 financing rounds [Dealroom, 2022]. The 2021 research additionally covers Ukraine.

Cumulative total value of VC fund investments in 2021 in all the analysed CEE countries was EUR 3.2 billion, which was over three times higher than in 2020 (EUR 0.95 billion). Average cumulative value of VC fund investments in this period was EUR 244 million. In 221 Estonia, Czech Republic, Poland and Lithuania made in total 68% of total VC investments in the CEE region. The volume of VC investments in 2021 was EUR 550 million and was over two times higher than the year before. Cumulative number of VC financing rounds in 2021 in all the analysed CEE countries was 559. The highest number of financing rounds provided by VC funds was found for Poland, which was responsible for 36% of investment rounds in the entire region. Average value of a single investment round in Poland was EUR 2.7 million, while in Estonia, where last year the biggest volume of investment was recorded, it was over EUR 12 million.

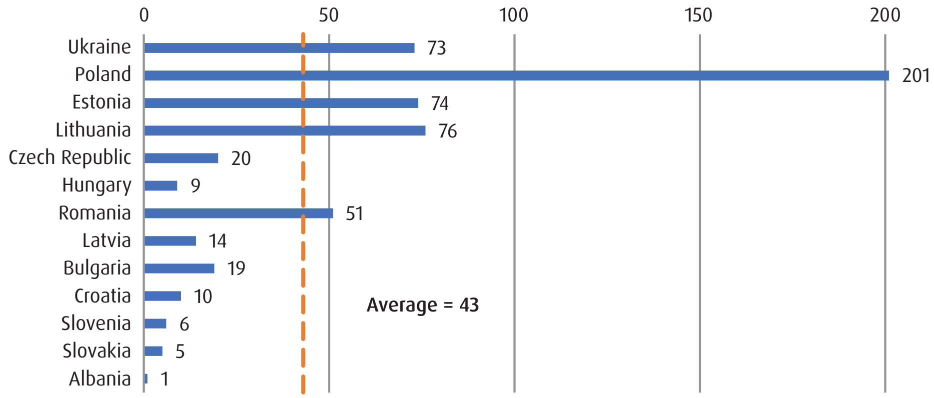
The highest value of transactions in 2021 was found in Estonia, Czech Republic, Poland and Lithuania. The biggest drop in investment volume, compared to 2020, was observed in Romania. Average value of a single investment round in Estonia was almost 4.5 times higher than the average value recorded in Poland.

Figure 2. Cumulative value of VC investments in 2021 (EUR million)



Source: self-reported data based on Dealroom [2022].

Figure 3. Cumulative number of VC financing rounds in 2021.



Source: self-reported data based on Dealroom [2022].

Case study

Poland: Planet Heroes

Polish start-up with its head office in Warsaw, which promotes environmentally friendly activities through its dedicated web platform. Planet Heroes is the first crowdfunding platform that specialises in obtaining funds for activities having beneficial environmental impact. The start-up's mission is to promote grass-root environmental initiatives and to provide opportunities to reward people who work for the benefit of our planet.

Planet Heroes platform is a place where people wanting to clean any natural area from litter and waste can contact entities ready to support them. The whole process comprises a few simple stages that can make our planet cleaner and more eco-friendly. Users who want to launch an Earth cleaning project log in on the platform, next they upload there photographs made, first, before cleaning the site, and then afterwards, and also pictures of properly sorted waste, placed in an appropriate place. Then the project is published on the platform and people interested in its development may send financial support to those who have undertaken to carry out the project.

In 2019, Planet Heroes were distinguished as one of the three best start-ups in the Green Startup Marathon, where the best green start-ups from all over the world were being presented, during UN Science-Policy-Business Forum on the Environment held in Nairobi, Kenya. In 2020 Planet Heroes received CVC YOUNG INNOVATOR AWARD for tech start-ups for socially useful and innovative undertakings. The competition was organised under MIT Enterprise Forum CEE Acceleration Program.

In 2022 Planet Heroes launched a platform called Hero to Hero, because of the war in Ukraine. Its aim is to support refugees from Ukraine and those who help them. Just as the Planet Heroes platform, the process consists of a few simple stages. Users willing to help refugees browse through the map of places where support is needed, choose a tab with relevant fund-raising, where they can read about refugees' stories and lists of things they need, and then they declare their support or provide money. On the other hand, if a person or organisation wants to receive support, they register on the platform, describe the stories of people they help and upload pictures that show the situation of individual refugees.

Source: Planet Heroes [2022a, 2022b, 2022c] and Samsung Newsroom Polska [2020].

Synthesised evaluation and ranking of start-up support systems in CEE countries

In order to evaluate the development of a CEE country in terms of its start-up support system, the research team used the technique of weighted scoring, where each of the criteria was given a score from 1 (very low) to 5 (very high) by an expert responsible for research on that factor. Then each researcher scored individual countries based on the defined scale. Weights for weighted scoring were established for last year's research by the expert team and authors of this study, by binary comparison. This way a factor was compared with each other factor and a simple majority vote of experts decided about its weight. In the course of the research performed using the binary comparison method it was found that the weight of individual factors (adding up to 100%) comprising start-up support systems in CEE countries is as follows: VC – 18.18%, social and economic development – 15.45%, start-up accelerators – 14.55%, clusters – 13.64%, government agencies – 6.36%, taxes – 10%, recognisability of start-up success in their countries – 4.55%%, academic entrepreneurship – 6.36%, intellectual property right protection – 5.45%, regulatory sandboxes – 1.82%.

It was assumed in the Delphi method survey of the panel of experts that a synthesized measure (aggregate weighted scores for each factor) will make it possible to identify the most developed start-up support systems in CEE. The research team adopted three grades corresponding to their development rate. It was agreed that, to call a system a "leader" of the analysed group of countries in this year's study edition, its total score must be at least 80% of the number of points possible from 1 to 5 (4.00 and more). To be called a "rising star" a start-up support system had to receive in total from 60% to 79.99% of all the possible score (from 3.00 to 3.995 points). Those start-up support systems which were evaluated below 60% of the total score (below 3.00) are called "developing" systems. Results of the research identified two "leader" grade start-up support systems (Estonia, and Lithuania), four "raising star" grade systems (Czech Republic, Poland, Slovenia, Latvia) and seven "developing" systems (Slovakia, Bulgaria, Hungary, Romania, Ukraine, Croatia, Albania). Detailed findings are presented in tables 13 and 14.

Table 13. Ranking of start-up support systems in CEE

Position	Country	Total evaluation	Category	Change in the total score as compared to 2021	Position in the 2021 ranking
1	Estonia	4.59	leader	−0.17	1
2	Lithuania	4.05	leader	−0.19	2
3	Czech Republic	3.94	rising star	0.25	5
4	Poland	3.86	rising star	−0.16	3
5	Slovenia	3.35	rising star	0.08	6
6	Latvia	3.17	rising star	−0.53	4
7	Slovakia	2.90	developing	0.11	10
8	Bulgaria	2.81	developing	−0.25	8
9	Hungary	2.45	developing	−0.50	9
10	Romania	2.35	developing	−0.87	7
11	Croatia	2.07	developing	−0.30	12
12	Ukraine	1.94	developing	−0.60	11
13	Albania	1.56	developing	−0.74	13

Source: self-reported data.

Table 14. Detailed evaluation of factors comprising start-up support systems in CEE countries and aggregate score of each country compared to the entire region*

Criterion	Weight (%)	Albania	Bulgaria	Croatia	Czech Republic	Estonia	Lithuania	Latvia	Poland	Romania	Slovakia	Slovenia	Ukraine	Hungary
Development	15.45	0.46	0.62	0.46	0.62	0.46	0.77	0.46	0.77	0.62	0.62	0.62	0.46	0.46
Taxes	10.00	0.10	0.30	0.20	0.30	0.50	0.40	0.40	0.20	0.30	0.30	0.30	0.10	0.20
Intellectual property	5.45	0.16	0.11	0.11	0.22	0.27	0.22	0.22	0.16	0.05	0.05	0.27	0.16	0.05

cont. Table 14

Criterion	Weight (%)	Albania	Bulgaria	Croatia	Czech Republic	Estonia	Lithuania	Latvia	Poland	Romania	Slovakia	Slovenia	Ukraine	Hungary
Academic entrepreneurship	10.00	0.10	0.40	0.30	0.50	0.50	0.40	0.30	0.50	0.20	0.40	0.40	0.20	0.30
Government agencies	6.36	0.06	0.06	0.06	0.25	0.25	0.25	0.25	0.25	0.06	0.06	0.25	0.06	0.13
Accelerators	14.55	0.29	0.58	0.15	0.58	0.73	0.73	0.58	0.58	0.29	0.44	0.58	0.29	0.44
Sandboxes	1.82	0.02	0.05	0.02	0.05	0.05	0.09	0.09	0.07	0.05	0.07	0.05	0.02	0.09
Clusters	13.64	0.14	0.41	0.55	0.55	0.68	0.68	0.55	0.55	0.41	0.68	0.55	0.41	0.41
VC	18.18	0.18	0.18	0.18	0.73	0.91	0.36	0.18	0.55	0.18	0.18	0.18	0.18	0.18
Perception of start-ups based on their success	4.55	0.05	0.09	0.05	0.14	0.23	0.14	0.14	0.23	0.18	0.09	0.14	0.05	0.18
Total score	**100**	**1.56**	**2.81**	**2.07**	**3.94**	**4.59**	**4.05**	**3.17**	**3.86**	**2.35**	**2.90**	**3.35**	**1.94**	**2.45**

* Panel of experts used studies presented in the section dedicated to start-up support system factors in CEE. The research was conducted at SGH Warsaw School of Economics on 16 April 2021 (binary comparison) and on 20 April 2022.

Source: self-reported data collected to establish the weight of each criterion in the group of factors comprising the start-up support systems in CEE.

Start-ups and sustainable development

Sustainable development goals (SDG), specified in Agenda 2030 drawn up by the United Nations (UN) and adopted unanimously by 193 countries, are one of the main challenges of the contemporary world. In total 17 goals and 169 targets are supposed to lead to international sustainability in social, economic and environmental terms. This requires, however, real collaboration and determined efforts from all the participants of the social, economic and political life [Patterson, 2015].

Start-ups, as highly innovative enterprises, may contribute to supporting SDGs especially in those sectors where changes aimed at achieving sustainable development require new, hitherto unknown solutions. It will be possible to achieve the goals in a more effective manner only if each new start-up undertaking conforms to the Agenda 2030 principles already at the stage of creating their big picture, mission, shaping their organisational culture. It is also recommended that each entity make achieving not more than 1–2 goals a priority, so that the efforts are not dispersed among too many targets, which could in consequence depress its implementation effectiveness [Sustainable Network, 2022].

In the most developed countries, where the awareness of the need for systemic support for sustainable development is high, the market of green start-ups has been dynamically developing for a few years already [The Truic Team, 2022]. In CEE the process is slower, but the number of entities that align with the SDGs already at the prototype stage is growing. These businesses also prove that introduction of sustainability principles does not exclude economic viability of their enterprises.

This report describes some start-ups that actively aim to achieve goals and targets set in Agenda 2030. The analyses covered in particular entities that were:

- diversified in respect of their origin (within CEE);
- focusing on various sustainable development goals;
- successfully conforming to sustainability principles, thus being a real inspiration for further start-up undertakings in line with SDGs.

Summary

The research presented in the report, practical examples and case studies of successful enterprises show how individual CEE countries provide favourable conditions for innovation. Synthesized description of start-up support system is also presented, dedicated to CEE countries, developed on the basis of international comparison, taking into account available source data. The panel of experts was conducted with the Delphi method, and it managed to identify the most advanced CEE countries in respect their start-up support systems. It was accomplished by translating the total scores of the countries into the classification of leaders, rising stars and developing countries.

Identification of developed start-up support systems in CEE (Estonia, Lithuania) allows to conclude that it is important to popularise relevant knowledge and experience and to make repeated attempts to exercise institutional transfer of best practices to other countries of the region.

In this year's report the authors focused on the issues of sustainable development and described a few start-ups from different CEE countries that actively pursue such strategies in their business.

The authors made every effort to identify, analyse and interpret data used in the research and to prepare a synthesized evaluation of individual systems. The results also prove that further in-depth research is necessary, based on standardized, comparable data and a unified time series of the research, as well as testing and piloting target solutions before their implementation in the economic practice.

According to the authors, next stages of the research could be developed towards a broader analysis of efficiency of the support systems. The states, as social and economic entities, should manage public funds in a targeted and rational way. The team maintains its view, expressed in the previous edition of the report, that it is not difficult to build sophisticated and complex support systems. A challenge, however, for them is to be conducive to creating big, recognizable tech companies with a global range.

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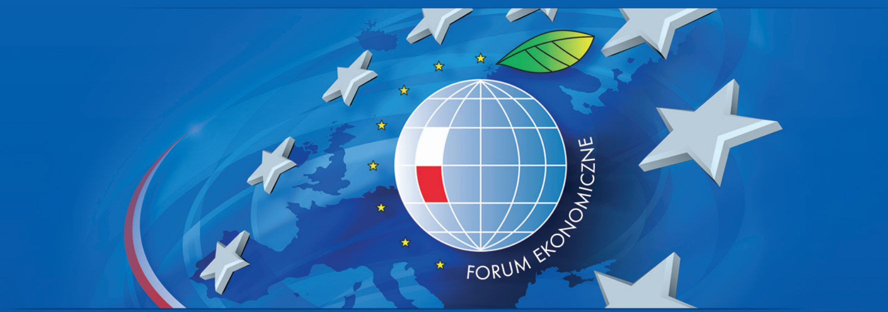

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