IMPACT OF GLOBAL SUPPLY DISRUPTIONS AND ENERGY PRICES ON INFLATION IN EUROPEAN COUNTRIES

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Economic Research and Statistics Department

NATIONAL BANK OF SERBIA

Belgrade, 12 Kralja Petra Street

Telephone: (+381 11) 3027 100

Belgrade, 17 Nemanjina Street

Telephone: (+381 11) 333 8000

www.nbs.rs

Impact of global supply disruptions and energy prices on inflation in European countries

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Abstract: The aim of this paper is to examine the extent to which global factors – supply chain disruptions and rising oil prices – affect inflation in Serbia and other European countries, this being particularly important in the context of the ongoing episode of global inflation growth, which is largely a consequence of the outbreak of the Covid-19 pandemic, but also of the energy crisis and the conflict in Ukraine. The analysis was carried out using the panel method, whereby an estimation was made for 31 European countries considered together and separately for European advanced and emerging economies. The analysis was carried out for the period from Q1 2006 to Q2 2023 using the panel ARDL model and estimates were obtained using the PMG and DFE methods, as well as the asymmetric ARDL model, where the inflationary impact of the rise and fall in global energy prices and of the tightening and easing of supply bottlenecks was tested separately.

The obtained results suggest that global supply chain disruptions have a statistically significant effect on consumer and producer prices in the long term, and global oil prices in both the short and long term (controlled for the influence of domestic factors). The link between inflation and supply bottlenecks has been confirmed for both advanced and emerging economies, as well as by various disruption indicators (the European Commission's Business Climate Indicator, measuring the level of disruption specific to a country, and the Fed's Global Supply Chain Pressure Index, gauging the intensity of global pressures), which indicates the robustness of the obtained estimates.

When the asymmetric ARDL model is applied, a higher coefficient is obtained for the indicator of global supply chain disruptions (measured by GSCPI) when a negative shock occurs (their loosening) than in the case of a positive shock (tightening), which is a consequence of the significant drop in this indicator in the last three quarters of the period analysed. This suggests that the obtained result is not robust in relation to the period analysed, which is why, before drawing final conclusions regarding this part of the analysis, the model should be re-evaluated once data for a few more quarters become available.

Keywords: inflation, global supply chain disruptions, energy, panel

[JEL Code]: C32, C33, E43

Non-technical summary

Price stability being its primary objective, the National Bank of Serbia devotes special attention to the analysis of inflation factors and the assessment of their character and strength. Generally speaking, central bank decisions have a greater impact on demand-side inflation factors, while they are considerably less effective when inflation is driven by factors on the supply side, especially those originating from the international environment. It is precisely these factors, caused by a series of negative shocks, that oiled the wheels of inflation growth, globally and in Europe, since early 2021.

The Covid-19 pandemic weighed down heavily on the production of intermediate goods and equipment amid reduced labour mobility and worldwide factory shutdowns, while the ensuing sudden opening of the economies brought about supply chain bottlenecks as the supply was unable to meet the globally pent-up demand in the short run. Things got worse in mid-2021 with the outbreak of the energy crisis in Europe that accelerated energy price growth, with spillovers to producer and consumer prices. The build-up of geopolitical tensions and the outbreak of the crisis and conflict in Ukraine in early 2022 made the already bad situation in the global energy and primary commodity market even worse.

The main motive for this analysis was the significant impact of supply chain disruptions and rising energy prices on the described accelerated inflation profile, with special reference to European countries, including Serbia, because they were affected by these factors more severely. The paper analyses the impact of these factors on inflation especially for advanced and emerging European economies, in order to see whether they were exposed to the effects of disruptions and higher energy prices to the same extent. The results show that in the long term these factors affect both consumer and producer prices in both groups of countries, though the impact of disruptions on consumer prices is somewhat stronger in advanced than in emerging economies, while in the case of producer prices the impact is similar.

Also, in order to understand the difference in the effect of global factors that lead to disruptions in supply chains and factors specific to each country, two different measures of disruption were used – the GSCPI, tracked by the Fed and showing global pressures, and the BCI, calculated by the European Commission within the ESI survey, which indicates problems in individual countries. The results show that in the long term, inflation is in all countries affected by both global and specific factors of supply chain disruptions, while the effect of the GSCPI is stronger in case of both consumer and producer prices.

Finally, it was analysed whether the inflationary effect of a positive cost shock, i.e. tightening of supply disruptions, is stronger than the disinflationary effect of a negative shock (easing of pressures in supply chains). The results showed that there is a long-run relationship between inflation and disruptions in both directions, with prices falling more when disruptions are resolved than rising when disruptions occur.

Contents

1 Introduction

The analysis of inflation factors is one of the most commonplace empirical analyses in world literature, and is particularly important for central banks. Monetary policy makers, whose main goal is generally price stability, assess the nature and character of inflationary pressures to calibrate the manner and degree of monetary policy response. An excessive monetary policy response can be as dangerous as an insufficient response and can deepen macroeconomic disturbances in the economy, which is why it should be ascertained exactly what factors determine inflation and to what extent. In general, practice has shown that monetary policies are more effective when inflationary pressures originate from the demand side rather than the supply side, and when they are driven by domestic rather than global factors. In other words, a central bank cannot resolve supply bottlenecks, nor reduce global energy and food prices, but it can contain the effects of domestic demand on inflation, as well as the effects of inflation expectations.

The impact of global factors on inflation becomes particularly pronounced with stepped-up trade, greater financial openness and the growing integration of countries into global value chains (GVC), i.e. with the process of globalisation, with inflation across countries becoming more synchronised. Some economists estimate that inflation is a largely global phenomenon [Ciccarelli and Mojon, 2010; Borio et al., 2017; Carney 2017], and that globalisation makes domestic inflation less dependent on constraints associated with domestic production capacities. Moreover, some authors [Borio et al., 2017] believe that global factors weaken the link between inflation and domestic economic activity (a decrease in the Phillips curve slope). As a result, in addition to the traditional concept of the Phillips curve, central bank inflation forecasting models are increasingly including various global factors to better explain inflation trends.

From 2013 until the outbreak of the Covid-19 pandemic, global factors mainly contributed to low inflation in most countries. This reflected slow global economic growth and low global energy and food prices, while inclusion in global supply chains, technological innovation and robust external competition curbed global inflation further by exerting pressure on companies to reduce own production costs and adjust to global trends. However, the situation has changed drastically in the last three years. In the initial phase of the Covid-19 pandemic, occasional production halts and a reduction in labour mobility dampened the supply of intermediate goods, spare parts (mainly semiconductors and microchips), machinery and equipment. With the sudden opening of economies after the vaccine development and growing global demand, the problems deepened further, as the supply was unable to meet the globally pent-up demand in the short run. This resulted in significant global supply disruptions, notably in manufacturing. In addition, the price of transportation also increased significantly, partly due to higher prices of energy products, notably oil, and partly elevated global demand, with significantly extended delivery deadlines. The magnitude of this problem is best illustrated by indicators of global supply disruptions (Global Supply Chain Pressure Index – GSCPI, Federal Reserve Bank NY) and the price of overseas container transport (Global Container Freight Index), which touched their historical highs in late 2021, triggering an increase in the general price level.

An additional problem concerning inflation was the outbreak of the energy crisis in the European market in October 2021, which pushed further up producer and import prices and spilled over to consumer prices of a wide range of products and services. The situation in the global market of energy and primary agricultural commodities has become more complicated since early 2022 with the intensification of geopolitical tensions and the outbreak of the crisis and conflict in Ukraine, so that in March and April 2022 the prices of these products reached or exceeded their historical highs. The crisis affected not only the prices of oil and grain (with Russia and Ukraine being significant exporters), but to a much greater extent also the prices and availability of natural gas, coal, electricity and numerous industrial and agricultural raw materials. Although in recent months these prices have mostly been declining and returning to pre-shock levels, the earlier elevated costs of production still continue to be passed on to inflation, which in many countries remains persistently high and above the target of central banks.

The above trends of global inflation in the past three years have been the main motive for the analysis presented in this paper, with a focus placed on the effects of global supply disruptions and global energy prices on inflation in European countries, including Serbia. The aim of the paper is to ascertain whether and to what extent these factors influenced inflation in emerging economies as well, as the hitherto analyses have mostly been carried out for advanced economies.

The paper is structured as follows – we first give an overview of literature and empirical findings related to the impact of global factors on inflation movements in advanced and emerging economies, with an emphasis on relevant recent papers that include the current episode of high global inflation and the impact of global supply disruptions on inflation. The econometric methodology used in the analysis is explained, and the data set is described. In a separate section, empirical findings are given for the entire sample, with a breakdown into advanced and emerging economies in order to examine potential differences and the robustness of the obtained ratings. The conclusion summarises the main findings of the analysis.

2 Channels of impact of global supply disruptions and energy prices on inflation

Although global supply disruptions have become a rather popular topic with the outbreak of the Covid-19 pandemic, it has a relatively long history in empirical and economic literature. In the pre-pandemic period, global supply disruptions were mainly caused by earthquakes, hurricanes, trade wars and geopolitical tensions. Lund et al. (2020) demonstrated that global supply disruptions lasting one month or longer occur every 3.7 years on average.

The first and direct channel of the impact of global supply disruptions and global energy prices on inflation manifests through the growth in import and producer prices, which are then passed on to consumer prices. The mismatch between the supply and demand of raw materials and intermediate goods, either through reduced supply, high demand or growing supply that still cannot meet the entire demand, and which reflects one of the above factors (geopolitical tensions, natural disasters, trade barriers, etc.), leads to shortages and drives up producer prices, which are then translated onto consumer prices.

The second channel of the impact of disruptions and global energy prices on inflation is indirect and takes place through inflation expectations. In an environment of rising inflationary expectations, primarily short-term, the current demand for these products increases due to the fear of shortages, while the expected rise in the prices of raw materials and intermediate goods is built in the current prices of products and services. Furthermore, amid tight labour markets, employees have the bargaining power to demand salary adjustments to keep pace with inflation, which in the current period leads to an increase in the economic cost. In the case of sufficiently strong shocks and the absence of an adequate economic policy response, this can lead to a self-sustaining spiral of prices and wages.

The third channel of a potential impact should not be disregarded either as the negative effects of global supply disruptions, i.e. shortages may be amplified by the so-called Forrester or the Bullwhip effect in distribution channels, where companies, amid the expected continued growth in demand, begin to accumulate stocks, further burdening supply chains, particularly in production.

3 Empirical literature

In the pre-pandemic period, a large number of empirical analyses about the impact of global factors on inflation were carried out, but the results were not unequivocal. For instance, the results of the analyses by Borio and Filardo (2007); Ciccarelli and Mojon (2010) indicate that growing globalisation and international factors, such as the prices of primary commodities and the pace of global economic growth, largely explain domestic inflation. Forbes (2019) points to similar conclusions. His analysis showed that the weakening of the link between domestic inflation and the level of economic activity can be explained precisely by global factors. Also, Auer et al. (2019) showed that the linkages resulting from the inclusion of countries in global supply chains influenced greater synchronisation of inflation (measured by producer prices), even in case of an incomplete spillover effect of the exchange rate on prices and that they account for around a half of global inflation. The linkages within GVC also amplify the effects of cost shocks on inflation. On the other hand, Ihrig et al. (2010); Forster and Tillmann (2014); Mikolajun and Lodge (2016); Bems et al. (2018) concluded that globalisation did not have a significant impact on inflation in advanced and emerging economies, while Kamber and Wong (2020) showed that external shocks, such as the global prices of primary commodities in emerging economies, had a stronger effect on the transitory rather than on the trend (permanent) component of inflation. In addition, Kamber et. al. (2020) showed that global oil prices and foreign GDP had a greater impact on inflation in emerging than in advanced economies in the 1996–2018 period.

The literature relating to the inflation analysis covering the period since the outbreak of the Covid-19 pandemic focuses mainly on the importance of global factors in explaining inflation trends. Benigno et al. (2022) constructed an indicator of global supply disruptions and estimated that their effect on inflation in the euro area and the USA, measured by consumer and producer prices, is significant. LaBelle and Santacreu (2022) combined sector-level measures of the GVC share with data on disruptions and delivery times to estimate US companies' exposure to disruptions in the global and domestic markets. Using the panel model, they estimated the impact of those disruptions on inflation measured by PPI for 26 sectors. The conclusion is that around 20 pp of producer price growth in the US manufacturing sector in late 2021 can be attributed to global supply disruptions and supply constraints. Further, Finck and Tillmann (2022) showed that global supply disruptions drove down consumer prices and impacted the economic downturn in the euro area, while Di Giovanni et al. (2022) state that the effect of global factors and global supply disruptions was stronger than domestic demand shocks on euro area inflation in 2020–2021. Muk and Postek (2023) evaluated the effect of material and equipment shortages (based on ESI indicators from a survey conducted by the European Commission) for a panel of European countries (EU members and candidates) on nine different measures of inflation that include consumer and producer prices. As shown by the analysis, disruptions have an inflationary character and affect the prices of products to a greater extent than those of services. The authors emphasize that the effect is more significant in the long than in the short run – based on the impulse response function obtained from the panel VAR analysis, it is concluded that the effect of disruptions on inflation is the strongest in the course of four–six quarters after the shock, and that it usually wanes within two–three years. In terms of the methodology used in this paper (panel ARDL and NARDL), Ye et al. (2023) showed that the impact of global supply disruptions is stronger in advanced (the USA, euro area, Japan, United Kingdom) than in emerging economies (China, South Korea, Taiwan), which is also true for oil prices.

4 Estimation methodology

The analysis of the impact of global supply disruptions and global energy prices on inflation in Serbia and other European countries was carried out based on a panel model, using estimates obtained by applying the PMG (pooled mean group) method and DFE (dynamic fixed effects), as well as the asymmetric ARDL model, where the impact of the increase and the easing of global supply disruptions on inflation is separately tested and the robustness of the estimates obtained using the symmetric ARDL model is verified.

The PMG method, developed by Pesaran, Shin and Smidth (1997), is based on pooling estimates for panel units and allows constants, short-run coefficients and error variances to vary across observation units, while long-run coefficients are constructed to be the same for all units of observation. The authors propose to estimate the following autoregressive distributed lag (ARDL) model of the p and q order:

$$\Delta y_{it} = \mu_i + \varphi_i(y_{i,t-1} - \Theta x_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \epsilon_{ij}$$

where the first difference of the dependent variable is regressed to delays of the dependent variable and independent variables in the first differences (short term), as well as those variables in the level (long-term relationship). The long-term coefficients, Θ, are defined to be the same for all units of observation. A negative and statistically significant value of the coefficient φ with error correction towards equilibrium confirms the presence of a long-term relationship between y_{it} and x_{it}. The equation is estimated using the maximum likelihood procedure.

The DFE method assumes that the coefficients in both long-term and short-term relationships, as well as the pace of adjustment, are the same for all units of observation, and that only the constants differ. Where the estimates obtained based on the PMG and DFE methods differ significantly, conclusions will be drawn based on the PMG method, as it allows for differences in estimates in a short-term relationship and the pace of adjustment, including greater panel heterogeneity and a lesser degree of restriction.

The non-linear panel of the ARDL model (Shin et al., 2014) is an extension of the linear ARDL model proposed by Pesaran, Shin and Smidth, who extracted positive and negative changes in disruption indicators in global value chains and tested the differences between these coefficients using the Wald test.

$$\Delta y_{it} = \mu_i + \varphi_i(y_{i,t-1} - \Theta_1^{+} x_{it}^{+} - \Theta_2^{-} x_{it}^{-}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^{+} \Delta x_{ij}^{+} + \sum_{j=0}^{q-1} \delta_{ij}^{-} \Delta x_{ij}^{-} + \epsilon_{ij}$$

Where x_{it}^{+} и x_{it}^{-} are obtained as:

$$x_{it}^{+} = \sum_{j=1}^{t} max(\Delta x_{ij}, 0)$$

$$x_{it}^{-} = \sum_{j=1}^{t} min(\Delta x_{ij}, 0)$$

Before the estimation, we applied different unit root tests in the panel [Im, Peseran and Shin (2003), Maddala and Wu (1999), Choi (2001)] as the ARDL model can be applied if the data series are used in the analysis of stationary or first order integration.

5 Data used in the analysis

In selecting data for analysis and estimation, we tried to find indicators that best describe the relationship between global supply disruptions and producer and consumer prices. Specifically, the paper examines the effects of two different measures of disruption in supply chains. The first measure is the Fed's Global Supply Chain Pressure Index (GSCPI). This composite measure consists of an index of ocean freight shipping and air cargo, as well as responses to questions from PMI (Purchasing Managers' Index) surveys related to the manufacturing supply chains of the world's leading economies. The second measure of disruption concerns one of the questions from the Business Climate Indicator (BCI) survey carried out by the European Commission at a quarterly level for the purpose of constructing the Economic Sentiment Indicator (ESI). ESI measures the share of companies that cite shortages of material and equipment as a factor constraining manufacturing growth. As expected, in the post-Covid-19 period, this measure exhibited a high degree of correlation with GSCP, with the following differences: 1) BCI measures the degree of disruption specific for a concrete country, while GSCPI is a measure of global pressures and; 2) GSCPI is calibrated based on those factors that impact inflation in seven major economies the most (China, euro area, Japan, South Korea, United Kingdom and the USA), while BCI focuses on European economies. We expect that the comparison of the effect of these two measures on inflation will provide some insight into the relative effect of global versus regional supply chain disruptions on inflation. Both of these variables are adjusted for the seasonal effect in their original form and are normalised so that their long-term average takes a zero value.

As a measure of inflation in European countries, in the preliminary analysis, we used the Harmonised Index of Consumer Prices (HICP) and its sub-index for industrial products. Furthermore, since we assume that chain disruptions are reflected most directly on industrial producers, we also used the Producer Price Index (PPI). All price data were taken from Eurostat, in the form of a monthly base index (2015=100). The data were seasonally adjusted using the TRAMO-SEATS method, wherafter quarterly averages were calculated and a log transformation was made. The first difference (quarterly seasonally-adjusted inflation) was also applied in the analysis of the short-term relationship.

Quarterly GDP, taken from Eurostat, was used as a measure of economic activity and was adjusted in terms of season and calendar. A log transformation was performed, as well as the first difference in evaluation of the short-term relationship.

The data on the nominal effective exchange rate were taken from the new Bruegel database [see Darvas (2021)], where the calculation of weights was performed based on 120 trading partners. A log transformation of the series was applied, and the series itself was constructed so that the index growth indicates appreciation.

As a general indicator of cost-push pressures on the side of primary commodities, the estimate relied on the global Brent oil price, whose trend approximates to a large extent the movement of other key primary commodities such as base metals, industrial raw materials and primary agricultural commodities. Oil price data are taken from the Refinitiv platform, and are expressed in dollars per barrel, with a log transformation also applied to this series. In the estimation process, in addition to the price of oil, the prices of primary agricultural commodities were also included, but they turned out to be multicollinear with oil prices, which is why we excluded them from further analysis.

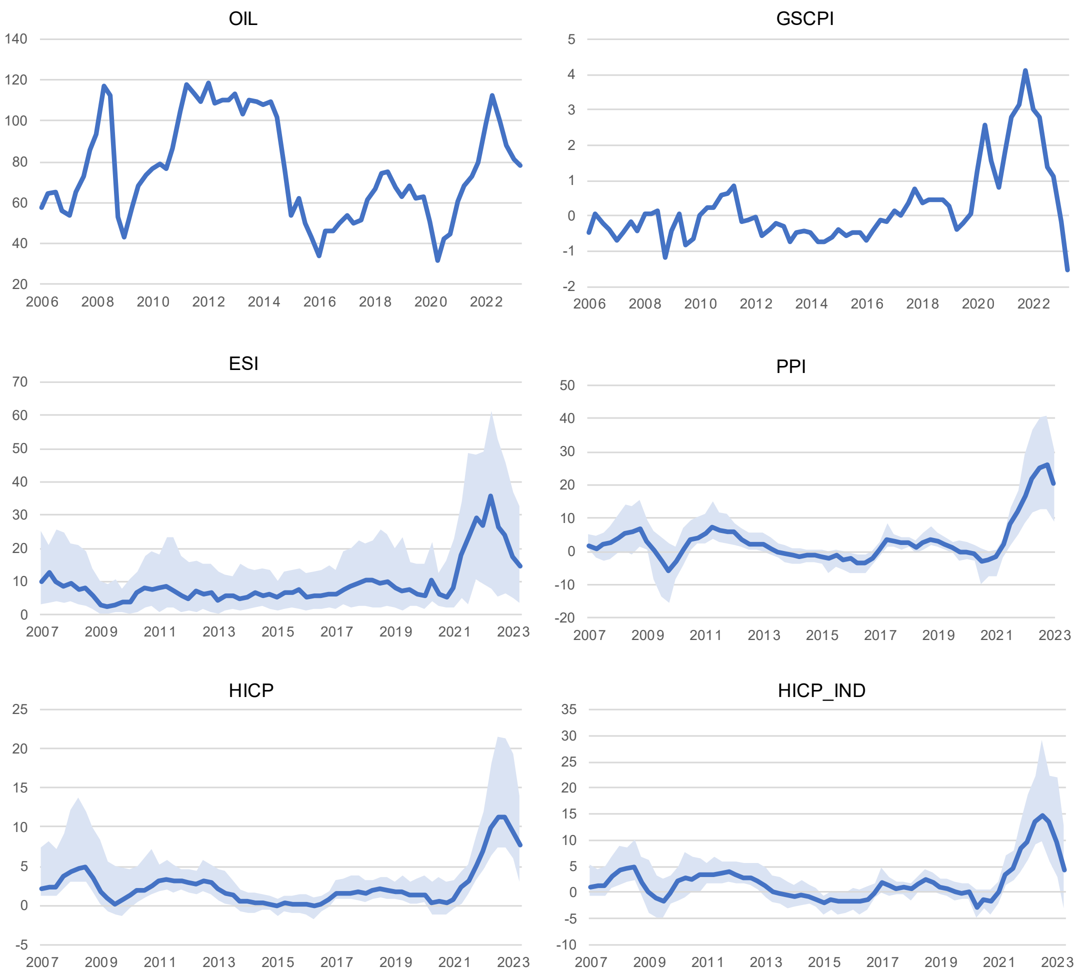
The complete list of series used in the model with their descriptions, sources and performed transformations is given in Table 1.

Table 1: **Description of data used in the analysis**

Designation in the model	**Description of the variable**	**Unit of measure**	**Source**	**Transformation in the long-run relationship equation**	**Transformation in the short-run relationship equation**
lhicp	Harmonised Index of Consumer Prices (HICP)	index, 2015=100	Eurostat	seasonally-adjusted, month to quarter, logarithm	seasonally-adjusted, month to quarter, logarithm, first difference
lhicp_ind	HICP of industrial products	index, 2015=100	Eurostat	seasonally-adjusted, month to quarter, logarithm	seasonally-adjusted, month to quarter, logarithm, first difference
lppi_ind	Producer Price Index (PPI)	index, 2015=100	Eurostat	seasonally-adjusted, month to quarter, logarithm	seasonally-adjusted, month to quarter, logarithm, first difference
loil	Brent oil	USD per barrel	*Refinitive*	month to quarter, logarithm	month to quarter, logarithm, first difference
ly	Gross domestic product	s-a level in constant prices	Eurostat	logarithm	logarithm, first difference
lneer	Nominal effective exchange rate	index, 2015=100	Bruegel database	logarithm	logarithm, first difference
esi	Response from the Business Climate Indicator survey Material and equipment shortages as a factor constraining production	% of companies	European Commission	-	first difference
gscpi	Global Supply Chain Pressure Index	standard deviation from the long-term average	*Federal Reserve Bank of New York*	-	first difference

Chart 1 shows the medians of the series included in the final estimation model, with an interval that excludes the first and last deciles of their variations. The Chart shows that the periods of inflation growth coincide with the periods of disruption in global/regional supply chains, as well as an increase in the global price of oil, but a more in-depth analysis requires an econometric assessment, which confirms this connection.

Chart 1: **Key series used in the analysis**



Note: The shaded field refers to values between the 10th and 90th percentiles.

6 Analysis results

Panel unit root tests (Im, Peseran and Shin (2003), Maddala and Wu (1999) ADF test), whose results are presented in Table 2, indicate that all series used in the analysis are stationary in level (loil, esi, gscpi, lneer) or in the first difference (lhicp, ly, lhicp_ind), which enables the application of the panel ARDL model.

Table 2: **Results of panel unit root tests**

	Im, Peseran, Shin mecm		*Maddala-Wu ADF mecm*	
Series	Model with a constant	Model with a constant and trend	Model with a constant	Model with a constant and trend
lhicp	11,929	3,544	4,918	49,28
loil	-8,339***	-4,896***	174,213***	107,274***
esi	-3,654***	-5,071***	168,763***	194,36***
gscpi	-4,682***	-1,2461	102,909***	56,832
lprim_agr	-12,476***	-8,689***	275,188***	176,71***
lgdp	5,246	-4,204***	26,097	132,347***
lneer	-2,567***	-3,967***	118,441***	128,891***
lhicp_ind	9,309	18,456	4,044	38,557
lppi	6,943	1,133	18,211	55,684
Δlhicp	-7,830***	-4,122***	204,857***	150,096***
Δgscpi	-35,737***	940,813***	-34,582***	880,698***
Δlgdp	-43,820***	-41,684***	1271,6***	888,454***
Δlhicp_ind	-11,041***	297,909***	-10,011***	273,003***
Δlppi_ind	-15,365***	372,655***	-14,392***	322,296***

Note: *** indicates statistical significance at 1%, ** at 5%, and * at 10%. The null hypothesis assumes non-stationarity for all panel units, and the alternative assumes stationarity for some panel units. The optimal number of delays was calculated on the basis of Akaike criterion.

In the next step, we estimated the relationship of headline inflation measured by HICP for all observed European countries for the period from Q1 2006 to Q2 2023 with a set of variables (consisting of indicators of global supply disruptions, global oil prices, level of economic activity and the nominal effective exchange rate). The results of the analysis and application of the PMG and DFE methods (Table 3) confirmed a statistically significant long-term relationship between the observed variables, whereby the coefficients for all variables proved to be statistically significant and have a logical sign, in accordance with economic theory. At the same time, the statistical significance of GSCPI, as a measure of disturbances in the global market, and of the European Commission's Business Climate Indicator, was confirmed, which indicates bottlenecks specific to a concrete country and region. When it comes to the short-run relationship, it is only the change in global oil prices and the nominal exchange rate that has the correct sign regarding the impact on inflation, while the change in GDP and disruptions in global chains, although affecting inflation, works in the opposite direction. The same conclusions are indicated by the estimates obtained when advanced economies and emerging European countries are observed separately,[1] and the results show a somewhat stronger impact of global supply disruptions (measured by GSCPI and BCI) in advanced rather than in emerging economies, which can be explained by their greater integration in global supply chains. The results indicate that an increase in GSCPI by one standard deviation leads to an

[1] The sample includes: Albania, Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Germany, Denmark, Finland, France, Greece, Estonia, Spain, Croatia, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, Montenegro, North Macedonia, the Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Serbia and Turkey. The classification made by the IMF was used as a criterion for the estimate, with the exception of Croatia, which has been a part of the euro area since the start of this year, but which in our analysis, given the entire period observed, is still classified as an emerging economy.

increase in the price level measured by the HICP by about 0.1–0.2%, while a 1% increase in global oil prices pushes up the price level between 0.2% and 0.3%. Growth in the net percentage of the companies which cite shortages of materials and equipment as a factor containing production growth in manufacturing by one unit leads to an increase in the price level between 0.02% and 0.05%.

Table 3 **Results of estimation of the ARDL model with headline inflation (d.lhicp) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1) PMG	(2) DFE	(3) PMG	(4) DFE	(5) PMG	(6) DFE	(7) PMG	(8) DFE	(9) PMG	(10) DFE	(11) PMG	(12) DFE
__ec												
loil	0.203***	0.218***	0.217***	0.276***	0.238***	0.241***	0.197***	0.198***	0.192***	0.204***	0.186***	0.243***
gscpi	0.134***	0.171***			0.165***	0.194***			0.096***	0.106***		
lneer	-0.741***	-1.109***	-0.676***	-1.312***	-1.953***	-0.736	-0.74		-0.643***	-0.850***	-0.602***	-0.866***
ly	1.075***	0.647***	1.325***	1.475***	1.418***	0.703***	1.237***	1.116***	0.915***	0.679***	1.292***	1.231***
esi			0.040***	0.022***			0.048***	0.018***			0.030***	0.029***
SR												
__ec	-0.020***	-0.016***	-0.016***	-0.010***	-0.016***	-0.012***	-0.011***	-0.011***	-0.030***	-0.032***	-0.034***	-0.025***
D.loil	0.011***	0.013***	0.013***	0.016***	0.012***	0.012***	0.014***	0.014***	0.010***	0.013***	0.011***	0.017***
D.gscpi	-0.003***	-0.003***			-0.003***	-0.002***			-0.004**	-0.005***		
D.lneer	-0.054***	-0.081***	-0.074***	-0.096***	-0.044**	-0.044***	-0.064***	-0.054***	-0.064***	-0.087***	-0.099***	-0.108***
D.ly	-0.034***	-0.028***	-0.028***	-0.022***	-0.036***	-0.015**	-0.026**	-0.011	-0.043	-0.054**	-0.037*	-0.046**
LD.lhicp	0.450***	0.488***	0.360***	0.506***	0.413***	0.499***	0.322***	0.500***	0.510***	0.450***	0.460***	0.439***
LD.lneer	-0.057***	-0.059***	-0.059***	-0.060***	-0.052***	-0.040***	-0.065***	-0.045***	-0.044**	-0.068***	-0.043**	-0.075***
D.esi			-0.000***	-0.000***			-0.000***	-0.000***			-0.001***	-0.000***
_cons	0.046***	0.094***	0.008***	0.028*	0.101***	0.048*	0.015***	-0.015	0.076***	0.143***	0.013***	0.041
N	2,038		1,934		1,474		1,422		564		512	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Similar estimates, in terms of the statistical significance of the impact of individual factors on prices, are also obtained in the case of inflation measured by consumer prices of industrial products (Table 4), as well as industrial producer prices (Table 5). As expected, the impact of global supply disruptions turned out to be the strongest in case of industrial producer prices, which is also true for the impact of global oil prices, as producer prices directly depend on production costs. It was ascertained that in advanced economies, global supply disruptions, measured by GSCPI, have a stronger impact on the prices of industrial products than on headline inflation, i.e. service prices are less sensitive to global supply disruptions than industrial products, which is, however, not ascertained for emerging economies or for the BCI measure of disruption. Compared to the impact of global oil prices, the impact of global supply disruptions, measured by GSCPI, is slightly lower for consumer prices, while in the case of producer prices, its strength is almost the same. The impact of the BCI measure of disruption on industrial producer prices, however, turned out to be more significant in the case of emerging economies than in advanced economies, which is contrary to the estimates obtained for consumer prices.

In the next step of the analysis, we applied the asymmetric ARDL model. In this case, too, a statistically significant connection between global supply disruptions and total consumer prices (Table 6), as well as the prices of industrial products (Table 7), was confirmed. However, it turns out that the negative shock of supply disruptions has a greater effect on prices, i.e. that prices fall more when disruptions are resolved rather than rise when disruptions occur, which is contrary to our expectations. The Wald test results indicate that the difference in the price impact is statistically significant in case of GSCPI as a measure of disruption, contrary to BCI where the difference is generally not statistically significant.

Table 4 **Results of estimation of the ARDL model with industrial product inflation (d.lhicp_ind) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE
__ec												
loil	0.247***	0.306***	0.265***	0.283***	0.272***	0.395***	0.216***	0.245***	0.240***	0.217***	0.224***	0.216***
gscpi	0.144***	0.188***			0.182***	0.251***			0.074***	0.081***		
lneer	-0.609***	-1.017***	-0.732***	-0.974***	-1.262***	-0.666			-0.615***	-0.840***	-0.699***	-0.783***
ly	0.566***	0.281***	0.876***	0.874***	0.703***	0.329**	0.532***	0.672***	0.591***	0.386***	0.821***	0.681***
esi			0.037***	0.017***			0.038***	0.015***			0.024***	0.016***
SR												
__ec	-0.034***	-0.027***	-0.024***	-0.023***	-0.029***	-0.022***	-0.022***	-0.027***	-0.047***	-0.044***	-0.050***	-0.046***
D.loil	0.029***	0.031***	0.035***	0.036***	0.029***	0.028***	0.035***	0.033***	0.031***	0.036***	0.031***	0.040***
D.gscpi	-0.006***	-0.005***			-0.005***	-0.005***			-0.006***	-0.006***		
D.lneer	-0.148***	-0.143***	-0.178***	-0.168***	-0.153***	-0.104***	-0.188***	-0.120***	-0.126***	-0.161***	-0.158***	-0.185***
D.ly	-0.039**	-0.021*	-0.02	-0.008	-0.031	-0.003	-0.016	0.009	-0.068**	-0.070***	-0.033	-0.049*
LD.lhicp_in	0.225***	0.238***	0.206***	0.285***	0.209***	0.189***	0.200***	0.249***	0.219***	0.307***	0.205***	0.335***
LD.lneer	-0.108***	-0.087***	-0.125***	-0.087***	-0.118***	-0.083***	-0.160***	-0.089***	-0.064***	-0.073***	-0.047	-0.075***
D.esi			-0.001***	-0.000***			-0.000***	-0.000***			-0.001***	-0.000**
_cons	0.129***	0.179***	0.061***	0.089***	0.180***	0.098**	0.023***	0.011	0.170***	0.252***	0.141***	0.180***
N	2,037		1,934		1,474		1,422		563		512	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 **Results of estimation of the ARDL model with the change in industrial producer prices (d.lppi_ind) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE	PMG	DFE
__ec												
loil	0.254***	0.286***	0.227***	0.304***	0.259***	0.252***	0.132***	0.196***	0.300***	0.345***	0.465**	0.360*
gscpi	0.246***	0.281***			0.275***	0.261***			0.212***	0.276***		
lneer	-1.170***	-1.214***	-1.871***	-0.508	-2.255***	-1.233**			-0.594***	-0.895***	-1.002**	-0.525
ly	0.598***	0.031	1.381***	1.655***	0.645***	-0.07	0.550***	0.747***	0.864***	0.639**	2.564***	2.664**
esi			0.097***	0.029***			0.055***	0.020***			0.100**	0.051
SR												
__ec	-0.039***	-0.034***	-0.012***	-0.016***	-0.036***	-0.038***	-0.022***	-0.025***	-0.042***	-0.031***	-0.022***	-0.016
D.loil	0.048***	0.048***	0.065***	0.064***	0.049***	0.048***	0.063***	0.062***	0.046***	0.050***	0.060***	0.066***
D.gscpi	-0.006***	-0.005***			-0.006***	-0.006***			-0.007**	-0.005***		
D.lneer	-0.429***	-0.422***	-0.514***	-0.474***	-0.414***	-0.439***	-0.512***	-0.463***	-0.458***	-0.415***	-0.540***	-0.480***
D.ly	0.004	0.02	-0.004	-0.006	-0.001	0.021	-0.016	0	0.007	0.003	0.007	-0.025
LD.lppi_in	0.283***	0.319***	0.285***	0.404***	0.275***	0.317***	0.270***	0.397***	0.270***	0.316***	0.283***	0.405***
LD.lneer	-0.01	0.076***	-0.026	0.092***	-0.006	0.047	-0.094	0.047	0.011	0.086**	0.094	0.123***
D.esi			0	0.000**			0	0.000*			0	0
_cons	0.241***	0.305***	0.067***	-0.032	0.398***	0.369***	0.028***	0.007	0.089***	0.132	-0.113***	-0.114
N	1,880		1,796		1,406		1,354		474		442	

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6 **Results of estimation of the asymmetric ARDL model with headline inflation (d.lhicp) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1) PMG	(2) DFE	(3) PMG	(4) DFE	(5) PMG	(6) DFE	(7) PMG	(8) DFE	(9) PMG	(10) DFE	(11) PMG	(12) DFE
__ec												
loil	0.205***	0.207***	0.211***	0.282***	0.235***	0.224***	0.190***	0.231***	0.179***	0.191***	0.191***	0.242***
gscpidec	0.218***	0.240***			0.239***	0.262***			0.193***	0.166***		
gscpiinc	0.086***	0.124***			0.116***	0.133***			0.044***	0.072***		
lneer	-0.722***	-1.118***	-0.682***	-1.316***	-1.591***	-0.513	-0.661		-0.724***	-0.868***	-0.608***	-0.861***
ly	0.979***	0.598***	1.287***	1.493***	1.282***	0.637***	1.182***	1.114***	0.775***	0.614***	1.281***	1.231***
esidec			0.041***	0.020***			0.047***	0.015***			0.032***	0.030***
esiinc			0.040***	0.024***			0.046***	0.021***			0.032***	0.028***
SR												
__ec	-0.022***	-0.017***	-0.017***	-0.010***	-0.018***	-0.014***	-0.012***	-0.012***	-0.034***	-0.034***	-0.033***	-0.026***
D.loil	0.010***	0.012***	0.013***	0.016***	0.011***	0.011***	0.014***	0.012***	0.009**	0.012***	0.011***	0.017***
D.gscpidec	-0.004***	-0.003***			-0.003***	-0.003***			-0.004***	-0.005***		
D.gscpiinc	-0.002***	-0.002***			-0.002***	-0.002***			-0.002	-0.003***		
D.lneer	-0.036***	-0.079***	-0.078***	-0.096***	-0.031*	-0.039***	-0.072***		-0.036**	-0.086***	-0.097***	-0.109***
D.ly	-0.036***	-0.028***	-0.026***	-0.022***	-0.036***	-0.016**	-0.024**	-0.009	-0.048	-0.055**	-0.035	-0.046**
LD.lhicp	0.393***	0.467***	0.350***	0.507***	0.368***	0.471***	0.309***	0.498***	0.432***	0.426***	0.450***	0.440***
LD.lneer	-0.051***	-0.056***	-0.054***	-0.060***	-0.051***	-0.039***	-0.059***		-0.033*	-0.062***	-0.045**	-0.075***
D.esidec			-0.000***	-0.000***			-0.000***	-0.000***			-0.001***	-0.000**
D.esiinc			-0.000***	-0.000***			-0.000***	-0.000***			-0.001***	-0.000**
_cons	0.059***	0.106***	0.012***	0.027*	0.092***	0.045*	0.015***	-0.018*	0.124***	0.167***	0.014***	0.041
Wald test for long-run relationship (p -value)	0.000	0.000	0.934	0.255	0.000	0.000	0.676	0.079	0.000	0.006	0.874	0.698
N	2,038		1,934		1,474		1,422		564		512	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 **Results of estimation of the asymmetric ARDL model with industrial product inflation (d.lhicp_ind) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1) PMG	(2) DFE	(3) PMG	(4) DFE	(5) PMG	(6) DFE	(7) PMG	(8) DFE	(9) PMG	(10) DFE	(11) PMG	(12) DFE
__ec												
loil	0.246***	0.290***	0.268***	0.302***	0.277***	0.361***	0.225***	0.267***	0.205***	0.205***	0.207***	0.216***
gscpidec	0.211***	0.251***			0.241***	0.314***			0.136***	0.133***		
gscpiinc	0.098***	0.139***			0.145***	0.176***			0.030***	0.055***		
lneer	-0.688***	-1.019***	-0.751***	-0.985***	-1.112***	-0.449			-0.708***	-0.854***	-0.685***	-0.783***
ly	0.489***	0.234***	0.883***	0.919***	0.655***	0.270**	0.551***	0.724***	0.476***	0.320***	0.809***	0.683***
esidec			0.039***	0.014***			0.037***	0.012***			0.026***	0.016***
esiinc			0.040***	0.020***			0.041***	0.019***			0.020***	0.016***
SR												
__ec	-0.038***	-0.029***	-0.022***	-0.022***	-0.031***	-0.025***	-0.021***	-0.025***	-0.059***	-0.047***	-0.055***	-0.046***
D.loil	0.028***	0.030***	0.034***	0.036***	0.027***	0.027***	0.034***	0.033***	0.028***	0.036***	0.031***	0.040***
D.gscpidec	-0.006***	-0.006***			-0.005***	-0.005***			-0.007***	-0.007***		
D.gscpiinc	-0.004***	-0.004***			-0.004***	-0.004***			-0.004**	-0.004***		
D.lneer	-0.129***	-0.139***	-0.184***	-0.168***	-0.144***	-0.098***	-0.194***	-0.115***	-0.095***	-0.160***	-0.153***	-0.185***
D.ly	-0.039*	-0.022*	-0.019	-0.01	-0.032	-0.005	-0.012	0.007	-0.067*	-0.067***	-0.033	-0.049*
LD.lhicp_ind	0.176***	0.214***	0.199***	0.285***	0.177***	0.163***	0.186***	0.247***	0.136**	0.282***	0.204***	0.335***
LD.lneer	-0.097***	-0.081***	-0.110***	-0.087***	-0.111***	-0.077***	-0.139***	-0.088***	-0.051***	-0.069***	-0.053	-0.075***
D.esidec			0	-0.000***			0	-0.000***			-0.001**	-0.000*
D.esiinc			-0.000**	-0.000***			-0.000*	-0.000***			-0.001*	-0.000*
_cons	0.170***	0.202***	0.058***	0.079**	0.173***	0.098*	0.019***	0.002	0.278***	0.288***	0.159***	0.179**
Wald test for long-run relationship (p -value)	0	0	0.726	0.059	0	0	0.176	0.05	0	0.007	0.043	0.959
N	2038		1934		1474		1422		564		512	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This result, however, is not robust for the period for which the estimation is made. Namely, if the estimation is carried out as at the last quarter of 2021, when the indicators of global supply disruptions were at their peak, it turns out that positive shocks in disruptions have a stronger impact on consumer prices than negative ones. The practical inclusion of the disruption resolution period in 2022, which continued into this year, statistically significantly changes the result, which is why, before drawing final conclusions regarding the asymmetric effect of a disruption on consumer prices, the model should be re-evaluated once data for a few more quarters become available.

The results are somewhat different when examining the impact of global supply disruptions measured by BCI on industrial producer prices (Table 8). In this case, it turns out that a positive shock has a stronger impact on producer prices than a negative one, and that the difference is statistically significant, i.e. in the case when disruptions deepen rather than when they are resolved, above all for advanced economies. Moreover, in this case, it turns out that disruptions have a positive impact on inflation even in the short term, although this impact is very small.

Finally, the asymmetric ARDL model was estimated. The impact of positive and negative shocks in the movement of global oil prices on consumer and producer prices was examined, but the differences were not statistically significant in any case, which is why these results are not shown.

Table 8 **Results of estimation of the asymmetric ARDL model with a change in industrial producer prices (d.lppi_ind) as a dependent variable**

	Full sample				Advanced economies				Emerging economies			
	(1) PMG	(2) DFE	(3) PMG	(4) DFE	(5) PMG	(6) DFE	(7) PMG	(8) DFE	(9) PMG	(10) DFE	(11) PMG	(12) DFE
__ec												
loil	0.243***	0.266***	0.254***	0.457**	0.254***	0.237***	0.167***	0.287***	0.271***	0.313***	0.502**	0.406
gscpidec	0.256***	0.303***			0.282***	0.276***			0.245***	0.318***		
gscpiinc	0.213***	0.243***			0.258***	0.227***			0.166***	0.227***		
lneer	-1.008***	-1.157***	-0.614**	-0.611	-2.181***	-1.106**			-0.582***	-0.872***	-1.081**	-0.543
ly	0.572***	-0.002	1.638***	2.278***	0.641***	-0.091	0.951***	1.051***	0.782***	0.520**	2.626***	2.914*
esidec			0.047***	0.012			0.040***	0.010**			0.092**	0.044
esiinc			0.065***	0.052**			0.053***	0.034***			0.117**	0.06
SR												
__ec	-0.042***	-0.038***	-0.022***	-0.012**	-0.037***	-0.042***	-0.020***	-0.020***	-0.049***	-0.035***	-0.022**	-0.015
D.loil	0.047***	0.047***	0.061***	0.063***	0.049***	0.047***	0.063***	0.062***	0.044***	0.049***	0.057***	0.066***
D.gscpidec	-0.006***	-0.006***			-0.006***	-0.006***			-0.007***	-0.006***		
D.gscpiinc	-0.005***	-0.005***			-0.005***	-0.005***			-0.005*	-0.004**		
D.lneer	-0.410***	-0.414***	-0.497***	-0.466***	-0.408***	-0.429***	-0.481***	-0.448***	-0.404***	-0.409***	-0.569***	-0.481***
D.ly	0.005	0.024	-0.007	-0.015	0.001	0.024	-0.026	-0.011	-0.002	0.008	0.047	-0.026
LD.lppi_ind	0.278***	0.311***	0.289***	0.392***	0.278***	0.312***	0.278***	0.383***	0.250***	0.299***	0.292***	0.405***
LD.lneer	-0.016	0.075***	-0.007	0.086***	-0.004	0.044	-0.083	0.047	-0.008	0.086**	0.157	0.119***
D.esidec			0.001*	0.000***			0.001**	0.000**			0	0
D.esiinc			0	0			0	0			0	0
_cons	0.239***	0.335***	-0.032***	-0.06	0.399***	0.387***	-0.014***	-0.029	0.125***	0.171**	-0.115**	-0.12
Wald test for long-run relationship (p -value)	0.01	0.023	0.003	0.037	0.299	0.086	0.01	0.017	0.008	0.085	0.242	0.48
N	2,038		1,934		1,474		1,422		564		512	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

7 Conclusion

The aim of this paper was to examine the effects of global cost-push pressures on consumer and producer price growth in European countries, including Serbia. The estimate of the nature of inflationary pressures is important for central banks as they also determine the monetary policy response. In conditions when inflationary pressures are driven by supply-side factors (such as supply chain disruptions and the energy crisis), monetary policy should, as a rule, only act to contain the second-round effects of price shocks, through the channels of expectations and earnings. On the other hand, monetary policy can directly affect demand-side shocks.

The importance of examining the effects of global cost-push pressures has increased particularly since 2020, when the presence of a series of supply-side shocks led to a rise in inflation in a vast majority of countries. This primarily concerns global supply disruptions caused by the pandemic, as well as the effects of the energy crisis and the Ukraine conflict, which mainly affected food and energy prices, including the prices of products and services within core inflation. Although there is a consensus about the nature of this shock, the extent to which global versus domestic factors, as well as demand-side versus supply-side factors, have affected prices and their effects in the short or long term has been the subject of numerous studies, with mixed results obtained.

With that in mind, we applied the ARDL methodology to a panel of 31 European countries, including Serbia, to assess the long- and short-term relationship of global cost-push pressures. The total Consumer Price Index, including its component related to industrial products, as well as the Producer Price Index, were used as dependent variables, in order to determine whether this relationship is present and equally strong in different stages of the production chain. The European Commission's Business Climate Indicator (BCI), which measures the level of disruption specific to a concrete country, and the Global Supply Chain Pressure Index (GSCPI), which reflects the global level of disruption to a greater extent, were used to measure disruptions in supply chains. As control variables, we used the real GDP as a measure of domestic aggregate demand, the global oil price as a measure of cost-push pressures of prices of primary commodities, and the real effective exchange rate as a measure of real marginal costs of net importers.

The obtained results are consistent with the results of other empirical research on this topic. A statistically significant long-term relationship was obtained between the cost factors – global supply disruptions and the global oil price, controlled for the influence of domestic factors, for both measures of disruption, which confirms that the pressures originated from both global and country-specific factors. In the short term, a significant relationship was obtained between the global price of oil and domestic inflation, which is not present in the case of global supply disruptions, which leads to the conclusion that they produce effects in the long term. The results of the estimation at the level of the entire sample for global disruptions show that an increase in GSCPI by one standard deviation leads to an increase in the overall price level by about 0.1–0.2%, while an increase in global oil prices by 1% results in an increase in the price level between 0.2% and 0.3%. When it comes to specific disruption factors by country (measured by BCI), the strength of the impact on headline inflation at the level of the entire sample of countries is somewhat weaker.

A statistically significant relationship was also confirmed when it comes to other measures of inflation – consumer prices of industrial products and industrial producer prices. Generally speaking, the effect of cost-push pressures, both in respect of disruptions and primary commodity prices, was the strongest on industrial producer prices, which is logical because producer prices are directly dependent on production costs, and this holds true both for advanced and emerging economies. However, in the case of advanced economies, a stronger impact of global disruptions and the global oil price on consumer prices of industrial products was observed in relation to headline inflation, which indicates that the remaining part of inflation, which mainly consists of service prices, is not sensitive to the examined external shocks to the same extent.

On the other hand, when it comes to emerging economies, the impact of cost-push pressures based on the oil price is significantly stronger than the impact of global disruptions on industrial producer prices in advanced economies, partly due to the structure of the industry in terms of the dominance of sectors at a lower level of technological development, and partly due to the lower efficiency of technological processes in the industry. In addition, in emerging economies, the impact of specific factors of supply chain disruptions on industrial producer prices is more significant compared to advanced economies, while opposite estimates were obtained in the case of consumer prices.

When it comes to the impact of control variables, the impact of a change in real GDP is stronger in advanced economies for both consumer prices of industrial products and industrial producer prices, which could indicate that prices in advanced economies are more elastic based on demand, which may also be explained by stronger market competition.

Furthermore, we applied the asymmetric ARDL model, in order to determine whether the inflationary effect of a positive cost shock, i.e. increase in supply disruptions is stronger than the disinflationary effect of a negative shock (the easing of pressures in supply chains). Contrary to expectations, by examining the entire sample, we obtained a statistically significant difference in favour of the effects of a negative inflationary shock, i.e. prices fall more when disruptions are resolved rather than rise when disruptions occur. However, this finding is not robust in case of a truncated sample, i.e. the exclusion of the effects of the inflation episode from 2021, which is why, before drawing final conclusions regarding the asymmetric effect of a disruption on consumer prices, the model should be re-evaluated once data for a few more quarters become available.

In the following period, this analysis should be repeated once the current episode of a sharp drop in disruption costs measured by GSCPI ends, because as already mentioned, this reduces the robustness of the asymmetric ARDL model and yields results that are not fully aligned with economic theory.

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