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INFLATION MOVEMENTS IN THE EU IN CONDITIONS OF EXTERNAL SHOCKS

ABSTRACT: *This study examines the key factors driving inflation in the European Union (EU) member states, focusing on both cost-push and demand-pull effects. By analysing monthly data from January 2005 to February 2023, the study investigates how inflation dynamics have evolved over time, particularly in response to external shocks such as rising energy prices. Inflation reached its highest levels in recent decades in 2022, driven by a combination of cost-push factors, such as rising crude oil prices, and the demand-pull effects that emerged in late 2021. The study employs fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) methods to analyse long-run inflation determinants. These econometric techniques are used to address potential issues of endogeneity and serial correlation in the dataset, providing robust and reliable estimates of inflation trends across the EU. The findings reveal that inflation was initially driven by cost-push factors, but these pressures subsided as energy price growth decelerated. From October 2021 onwards, demand-pull effects became more pronounced as aggregate demand surged. Additionally, the study highlights significant disparities in how EU member states responded to external energy price shocks, underscoring the need for more coordinated EU energy policy. Its results suggest that EU policymakers need to implement more coordinated fiscal and energy policies to mitigate the impacts of external price shocks. Future research should focus on country-specific drivers of inflation and assess the long-term effects of coordinated energy strategies within the union. This study contributes to the literature by using advanced econometric methods to analyse inflation dynamics over an extended period and provides valuable insights for policymakers, particularly in addressing the varying impacts of external shocks across EU member states.*

KEY WORDS: *inflation, cost-push factors, demand-pull effect, European Union*

JEL CLASSIFICATION: E32, E52, E43, F2

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1. INTRODUCTION

Consumer price inflation surged significantly at the end of 2021, particularly affecting fuel and food bills. This prompted heightened attention from the media and the public. The last comparable inflation spike in the EU occurred during the 2008 financial crisis, but key differences between the two episodes highlight unique underlying factors.

During the 2007–2008 crisis, inflation was primarily driven by rising raw material costs, partly due to China's rapid industrialisation and urbanisation. Domestically, increased demand and labour costs further fuelled inflation. In contrast, the recent inflation spike stems from imported inflation, the recovery in personal consumption, and statistical comparisons with the suppressed prices of 2020 caused by pandemic-related economic disruptions.

The post-pandemic recovery stimulated global demand, leading to higher energy and raw material prices. By the mid-2020, prices of grains, oilseeds, metals, and wood began climbing. Crude oil price increases quickly affected fuel prices and other costs, such as transportation and catering services. Shifting consumption patterns, such as higher demand for IT equipment and cars due to remote work, also contributed to price increases.

While demand recovered swiftly, supply-side disruptions proved more persistent. Global supply chain bottlenecks, including labour shortages, container scarcities, and pandemic restrictions, exacerbated costs. Weather-related issues, such as droughts and floods, further strained food supply chains, impacting raw material prices.

Russia's invasion of Ukraine in early 2022 triggered sharp increases in energy and commodity prices, particularly affecting Europe, which heavily relied on Russian oil and gas. Russia’s use of energy as a geopolitical tool further amplified inflationary pressures, pushing prices to levels not seen in decades, reminiscent of past energy crises.

Energy price increases became a significant driver of inflation divergence among euro area countries. Factors such as energy regulation, government support measures, energy generation mix, and the terms of household utility contracts influenced inflation outcomes. For instance, countries with fixed utility prices experienced delayed inflation transmission compared to nations with flexible pricing systems.

By October 2022, euro area inflation exceeded 10%, with member states experiencing rates ranging from 7% (France) to over 20% (the Baltic states). Slovenia's inflation stood at 10.3%, close to the euro area average. The pandemic initially caused disinflation in tourism-dependent economies but later drove inflation in countries with robust economic recoveries and labour shortages, which pressured wages.

While inflation variations may appear to disrupt the monetary transmission mechanism, they largely reflect external shocks and national-level differences in aggregate supply and demand reactions. Monetary policy cannot entirely offset external shocks, which interact with national fiscal policies, labour markets, and economic structures.

The analysis of inflation trends across EU member states reveals significant variation in how countries responded to the rising inflationary pressures. These differences can largely be attributed to the interplay of fiscal measures, energy policies, and the underlying economic structure of each nation, which shaped their vulnerability to external shocks, particularly thesurge in energy prices driven by the war in Ukraine

Fiscal measures:

Various EU countries applied fiscal measures to counteract inflation. For example, in 2022, Germany introduced an energy price cap for households and small businesses to mitigate the shock of rising energy costs. The government subsidised up to 80% of the cost of gas for households, capping prices at a fixed rate (Germany's ‘gas price brake’). This measure successfully alleviated inflationary pressures, as evidenced by the fact that Germany's inflation rate stabilised around 10.0% by mid-2022 after peaking at 10.5% in early 2022. Similarly, France implemented a fuel price rebate to help consumers manage soaring fuel costs, which significantly reduced inflationary pressures in the transport sector.

Monetary policy measures:

The European Central Bank (ECB) raised interest rates multiple times starting in July 2022 as part of their efforts to curb inflation. The ECB's interest rate hike from 0% to 1.25% by October 2022 was aimed at controlling demand-side inflationary pressures. This policy was in line with the ECB's mandate to maintain price stability within the euro area. However, the impact on inflation was mixed. Countries with higher inflation, such as Estonia and Lithuania, saw only a moderate slowdown in inflationary trends despite the rate hikes, suggesting that supply-side shocks (e.g., energy price spikes) were still predominant in driving inflation.

Energy policy measures:

Energy policies played a crucial role in shaping inflation trends across EU member states. The rising energy prices driven by the war in Ukraine created divergent inflationary pressures across the region. In countries such as Italy and Spain, where energy price caps were implemented, inflation rates were somewhat stabilised compared to countries with more exposed energy markets, such as the Baltic states. The Lithuanian government, for example, capped electricity prices for households at 22 cents per kWh in early 2022, limiting inflation in the energy sector and, in turn, moderating overall inflation. However, countries without such caps, or those more reliant on Russian energy supplies, experienced more significant inflationary pressure, with Latvia and Estonia's inflation rates peaking at over 20% in 2022.

Energy subsidies and tax measures:

Energy subsidies, particularly in the form of targeted support for low-income households, played a significant role in limiting inflationary pressures on vulnerable populations. The United Kingdom, for instance, introduced direct cash transfers to households to mitigate rising energy costs. The government also reduced VAT on fuel and electricity, which helped curb inflation by easing the burden on consumers. In contrast, Hungary's energy price cuts for households led to higher inflation in non-energy sectors due to the need to finance these subsidies.

Impact of policy on inflation:

In terms of aggregate inflation, these policies had mixed results. Countries with robust fiscal and energy policies, such as France and Spain, managed to keep inflation rates under control, despite global energy price shocks. In contrast, countries such as Estonia and Lithuania, where energy price rises were more abrupt and unmitigated by government measures, saw inflation spike to record levels. For instance, by the end of 2022, inflation in Estonia was recorded at 22.1%, while in Spain, despite high energy price inflation, it stabilised around 8.4% due to effective fiscal interventions, including energy subsidies and tax reductions. Similarly, the variation in inflation between the eurozone's core and peripheral countries illustrates the impact of domestic policy measures. Core countries, with stronger fiscal capacities and energy regulations, such as Germany, had more resilient inflation outcomes.

Aggregate supply elasticity and economic structure:

Aggregate supply elasticity is influenced by several factors, including competition, technological capacity, production flexibility, and the overall economic structure. Energy-intensive, industrial economies (e.g., Germany, Slovakia) were more vulnerable to energy price shocks and supply chain disruptions. Conversely, service-oriented, IT-driven economies (e.g., Ireland) adapted more effectively due to digital sector growth and lower exposure to energy price shocks. This disparity played a significant role in the regional variation of inflation trends.

Regional inflation trends and policy effects:

The Baltic states, heavily impacted by the war and sanctions, experienced sharp inflation increases. Pre-war, gas and electricity costs were relatively low, which amplified percentage increases during the crisis. Flexible price-setting in the region allowed faster pass-through of energy costs to consumer prices, further accelerating inflation. In Estonia, inflation was driven by flexible utility pricing contracts, which allowed immediate cost pass-through. Additionally, the pandemic's limited economic impact in the Baltic states, coupled with strong post-pandemic recovery and expansionary policies, amplified inflationary pressures. Estonia’s 2021 pension system reform, which allowed early withdrawals, boosted private consumption and inflation.

Country-specific energy price dynamics:

Malta maintained low inflation due to fixed energy prices secured through a long-term contract with Azerbaijan. In contrast, the Netherlands experienced an energy price explosion in March 2022, driven by external shocks and national energy policies. The differences in the energy generation mix and the terms of household utilities contracts across these countries also contributed to the divergence in inflation rates.

Inflation dynamics in the EU during 2021–2022 reflect a combination of global external shocks, domestic policy responses, and structural economic factors. Divergences across member states highlight the interplay of supply elasticity, energy policy, and fiscal measures in shaping inflation outcomes. These factors underscore the complexity of addressing inflation in an interconnected economic environment.

To analyse these inflation dynamics, this study employs advanced econometric methods: fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS). These techniques are utilised to address potential issues of endogeneity and serial correlation, providing robust and reliable estimates of the long-run determinants of inflation across the EU.

This study contributes to the empirical literature on inflation determinants in several ways. First, it provides a comprehensive analysis of the interplay between demand-side and supply-side factors driving inflation in the EU, considering both common shocks and country-specific dynamics. Second, it explores various transmission channels behind the recent inflation surge, including energy dependency, fiscal measures, and monetary policy constraints. Third, by examining inflation divergence among EU member states, the study highlights the role of structural economic factors in shaping inflation outcomes. Finally, it offers policy insights on how coordinated EU-wide measures could enhance inflation resilience, particularly in the context of external shocks and global supply chain disruptions.

The remainder of this study is organised as follows: Section 2 provides a brief overview of the relevant literature. Section 3 introduces the data used in the analysis and presents the variables. Section 4 describes our econometric methodology. Section 5 presents the empirical results and a variety of sensitivity checks aimed to confirm the baseline results and provide a more granular analysis. Section 6 draws conclusions with policy implications.

2. LITERATURE REVIEW

The causes of inflation have been extensively explored in the literature, with various theories offering insights into its underlying dynamics. In this study, we integrate two prominent economic theories – the demand-pull theory and the cost-push theory – to better understand the inflationary pressures observed in European economies.

The demand-pull theory, as proposed by Smith (2016), posits that inflation occurs when aggregate demand outpaces aggregate supply, leading to excess demand pressures in the economy. This theory emphasises the role of consumer spending, investment, and government expenditure as key contributors to inflation. When these components of demand rise too rapidly, they can drive an overheated economy, pushing prices upward. Smith's framework highlights the demand-side factors and their role in fuelling inflation, offering important insights into how consumption and investment behaviours can influence price levels.

In contrast, the cost-push theory, introduced by Gordon and Hall (1985), focuses on the role of rising production costs in driving inflation. According to this theory, inflation results from increases in wages, raw material prices, or other production inputs, which then get passed through the supply chain, leading businesses to raise prices to preserve profitability. Cost-push inflation underscores the significance of supply-side dynamics and suggests that inflation can occur even in the absence of excessive demand. This theory helps explain inflationary trends arising from rising input costs rather than excess demand

Empirical studies differ in their geographical focus: some analyse the entire EU, while others concentrate on the euro area or new EU member states. Methodologically, unit-root testing dominates, with both time-series and panel unit-root tests being common, alongside alternative approaches such as distributional analysis or wavelet methods to study convergence in the time-frequency domain. Benchmarks also vary, ranging from the Maastricht criterion to Germany's inflation rate, the ECB's 2% target, or cross-sectional averages. Consequently, findings on inflation convergence are diverse.

Given these variations, we focus on studies closely aligned with our analysis and recent contributions. For instance, Brož and Kočenda (2017) analysed inflation convergence in all 28 EU member states using data from 1999 to 2016. They employed three benchmarks: the cross-sectional average, the ECB's medium-term inflation target, and the Maastricht criterion. Using a seemingly unrelated regressions (SUR) framework with augmented Dickey-Fuller tests, they examined the impact of factors such as the global financial crisis and EU monetary policies. Their findings indicate that most EU member states converged toward all three benchmarks during the period. They also highlighted that price stability-oriented monetary strategies likely supported convergence, while the effects of implementing EU legal frameworks (acquis communautaire) were inconclusive.

Erdogan et al. (2020) investigated inflation determinants in 30 European countries from January to July 2020 using spatial panel data methods. Their results revealed that domestic money supply, exchange rate fluctuations, and spatial effects (neighbourhood relations) contributed significantly to inflation. These findings emphasise the role of monetary and exchange rate policies in influencing inflation across Europe.

Čaklovica and Efendić (2020) analysed inflation determinants in 28 transition economies in Europe from 2005 to 2015, employing dynamic panel modelling. They included variables such as economic openness, unemployment, real wages, and external factors such as food and oil prices. The study found that structural variables, such as unemployment and wage growth, played a significant role in both short- and long-term inflation dynamics. External supply shocks, particularly energy prices, had a notable long-term effect, while food prices influenced inflation only in the short term. Their results suggest that structural features and market rigidities amplify inflation inertia in transition economies.

Historical perspectives are provided by Schmelzing (2020) and Bonam and Smadu (2021), who examined the effects of pandemics on inflation using data spanning several centuries. Schmelzing's data, covering six European countries from 1313 to 2018, showed that major pandemics typically induced prolonged disinflation. However, Bonam and Smadu observed that the COVID-19 pandemic, with its unprecedented fiscal and monetary responses, led to upward inflationary pressures due to rapid economic recovery, supply chain disruptions, and rising costs passed on to consumers.

Binici et al. (2022) explored the post-pandemic rise in consumer price inflation across 30 European countries between 2002 and 2022 using generalised dynamic factor and local projection methods. They found that while global factors remained critical in shaping inflation dynamics, country-specific factors, such as monetary and fiscal policies, gained prominence during the pandemic. These findings highlight the interplay between global and domestic influences on inflation.

Moessner (2022) focused on short-term inflation expectations in the euro area, analysing survey data from 16 member countries using dynamic panel estimation. His study identified that food price inflation, oil prices, and global commodity prices significantly influenced inflation expectations. For instance, a 10% increase in food consumer price inflation raised expectations by 0.5 percentage points. Similarly, a 10% depreciation of the nominal effective exchange rate increased inflation expectations by 0.7 percentage points. Additionally, inflation expectations exhibited persistence and were positively linked to the output gap.

Overall, the literature demonstrates that inflation convergence and dynamics are influenced by a combination of structural, policy, and external factors. While some studies emphasise the role of monetary strategies and institutional frameworks, others highlight the impact of external shocks, global trends, and country-specific policies. These diverse perspectives underline the complexity of inflation behaviour in Europe, warranting further investigation into the mechanisms driving inflation convergence.

3. DATA AND VARIABLES

To analyse the determinants of inflation in EU countries, we construct a sample comprising all 27 EU member states. These include the original members (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Spain, and Sweden) and the 'newer' member states (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia). We then employ a panel regression analysis. Maddala and Wu (1999) argue that one of the main advantages of panel data compared to other types of data is that the approach allows for testing and adjustment of the assumptions that are implicit in cross-sectional analyses.

Most empirical studies define inflation as the percentage change in consumer price compared to the previous year (e.g., Catao & Terrones, 2006; Staehr, 2010). Some use GDP deflator changes (Alfaro, 2005) or real money value depreciation (Chrigui et al., 2011). The dependent variable is often logarithmic (logINF) to reduce outliers and account for non-linearities. Our study uses the Harmonised Index of Consumer Prices (HICP), a standardised measure across EU countries, ensuring comparability. The HICP is more reliable than CPI due to its harmonised methodology, broader coverage of goods and services, and inclusion of owner-occupied housing costs.

The first independent variable that we look at is the domestic output gap. Almost all studies that investigate the determinants of inflation as a measure of the output gap use the growth of real GDP, although different transformations of the variable are used in different studies, including primarily the level of GDP per capita (GDPPC), but also the percentage change in GDPPC, the GDP level, or even the GDP gap (Deniz et al., 2016; Staehr, 2010). Given the unavailability of the monthly GDP series in our cases, we will follow Binici et al. (2022) and use the seasonally adjusted Industrial Production Index (IPI) as a proxy to calculate the domestic output gap.

As a labour market factor, we include the rate of unemployment. The connection between unemployment and inflation began to preoccupy economists in the early decades of the last century and has been the subject of academic discussions for almost a whole hundred years. The curve describing this relationship, the Phillips curve, was named after the author of a study on the existence of a negative relationship between unemployment and inflation in the United Kingdom for the period from 1860 to 1957 (Phillips, 1958). More precisely, his work analyses the relationship between unemployment and inflation of nominal wages, but since the latter is closely related to the movement of the general price level, it can be easily identified. We will follow Kjosevski and Petkovski (2017) and take the logarithm of unemployment and test this relationship for the 27 EU countries.

The inclusion of the nominal exchange rate in inflation equations often represents the effect of monetary policy. According to the standard macroeconomic model, monetary expansion typically leads to a weaker currency, which stimulates growth and moderate inflation, resulting in an expected negative parameter for the EUR/USD exchange rate. However, this parameter reflects more complex relationships.

Depreciation of the domestic currency (e.g., the euro) can show increased demand from expansionary monetary policy but may also act as a cost-push shock. A weaker euro raises the cost of imported energy products, particularly when denominated in US dollars. Additionally, a depreciated euro can fuel inflationary expectations tied to the nominal exchange rate. Conversely, balance sheet effects, such as more expensive foreign currency debt, may contract aggregate demand by increasing debt burdens. Thus, the sign of the EUR/USD exchange rate parameter depends on macroeconomic shocks and economic structures. If negative, it may indicate either standard monetary expansion effects or cost-push dynamics.

This paper examines whether the nominal exchange rate materially affects inflation, thereby constraining the monetary policy of the ECB more than that of the Federal Reserve (the FED) of the United States (US). The inclusion of the EUR/USD exchange rate in the model also accounts for its interaction with oil prices (measured using the Brent benchmark, in US dollars). A weaker euro amplifies the impact of rising oil prices on inflation, while a stronger euro mitigates it. The significant role of oil prices on inflation has been extensively documented (e.g. Ghanem, 2012; Lin & Chu, 2013). Studies by Staehr (2010) and Globan et al. (2016) explored these effects for specific countries, including transition economies, demonstrating the global impact of energy price fluctuations on inflation.

Energy prices significantly influence inflation as they are a critical input across industries and households. Rising energy costs increase production expenses, transportation costs, and household utility bills, reducing disposable income and potentially contracting consumer spending. Central banks closely monitor energy prices to adjust monetary policy when inflation spikes due to higher energy costs. Higher inflation often leads to tighter monetary policies, slowing economic growth. Therefore, the impact of the global energy price impact on inflation is profound and far-reaching.

The Global Food Price Index also affects inflation, especially in developing economies where food constitutes a large share of household spending. Rising food prices increase living costs and production expenses, driving overall inflation. Trade restrictions often exacerbate local price pressures. Numerous studies (e.g., Ciccarelli & Mojon, 2010; Mohanty & Klau, 2001) highlight the global dimension of food price inflation. This study uses the Global Food Price Index (2016=100, in US dollars) as a variable to analyse its influence.

The Global Supply Chain Pressure Index (GSCPI) further illustrates inflation dynamics. Developed by the Federal Reserve Bank of New York, the GSCPI measures stress in global supply chains through such factors as port congestion, container availability, and transportation costs. Positive GSCPI values indicate supply chain pressures above the norm, often linked to producer price inflation in major consumer markets. Before 2020, the GSCPI rarely featured in economic studies, but supply chain disruptions during the COVID-19 pandemic brought it to prominence. The pandemic-induced shifts in demand, coupled with fiscal and monetary stimuli, strained global production networks. Supply bottlenecks emerged, driven by heightened demand for goods, idiosyncratic disruptions (e.g., weather events), and pandemic-related lockdowns. These bottlenecks contributed to inflationary pressures by limiting supply amid rising demand.

Supply chain disruptions peaked after the 2020 lockdowns eased but surged again in late 2021, with such events as Chinese lockdowns and port congestions exacerbating global inflation. Geopolitical risks further strained supply chains, challenging the globalisation model dominant since the late 20th century. These pressures underscore the interplay between supply chain dynamics and inflation. By analysing the GSCPI, this study sheds light on how global disruptions influence inflationary trends and central bank policymaking.

The role of monetary policy is inevitably included as a determinant of inflation and it is mainly observed through the patterns of monetary aggregates. Inflation is essentially a dynamic term, and by stopping the increase in the amount of money in circulation, prices are also stopped at a new level, without taking into account the new level of the amount of money in circulation. Inflation can also rise as a result of monetary policy, and this happens if the state issues money for its own account with the purpose of acquiring the purchasing power it lacks. When prices rise while the quantity of goods remains unchanged, the government may meet its needs by issuing more money, which fuels new inflationary cycles. As a result, inflation becomes difficult to control until economic conditions return to equilibrium. The concept of inflation is relative and arises when the quantity of money and the quantity of goods do not increase simultaneously or proportionally. Therefore, inflation can occur when the quantity of goods in circulation decreases, while the amount of money in circulation remains constant (Božina, 2008). The most widely used forms of this variable in the literature are the growth rates of monetary aggregates M2 (Deniz et al., 2016; Eftekhari-Mahabadi & Kiaee, 2015), M1 (Ghanem, 2012; Globan et al., 2016), the ratio of M1 to GDP (Catao &Terrones, 2015), and M3 (Agayev, 2012).

This paper uses M3 as the measure of the monetary aggregate because it encompasses a broader range of financial assets than M2, making it a more comprehensive indicator of inflationary pressures. Unlike M2, M3 includes assets such as stocks, bonds, and other instruments that individuals may use to store wealth during periods of rising inflation. Additionally, M3 can provide a better picture of changes in the money supply over time by including the financial assets not captured by M2. This can be especially important in times of financial instability, when traditional measures of money supply may not fully capture changes in the overall level of liquidity in the economy. Overall, while both M2 and M3 are important measures of money supply, M3 can provide a more comprehensive view of the overall level of liquidity in the economy and is often preferred by economists and central banks as a measure of inflation.

The recent acceleration of consumer inflation is to a certain extent also influenced by the war in Ukraine, primarily by increasing the price of energy and food raw materials. The price of natural gas rose sharply on the European market even before the outbreak of the war, reflecting weaker-than-usual supply, especially from Russia, and consequently low stock levels. Since the beginning of the war, the price of crude oil has also increased. In addition, since late February 2022, the prices of a number of other raw materials – mainly food supplied to the world market by Russia and Ukraine – have also risen. Taking this into account, we introduced a dummy variable in our model that has a value of 1 for the period 2022M2 to 2023M2, and 0 for the rest of the period.

The data for the selected variables were obtained from Eurostat (2024), the Federal Reserve Bank of St. Louis (FRED, 2024), and the Federal Reserve Bank of New York (2024). Table 1 presents the variables used in the model, along with their definitions, units, and data sources.

Table 1. Definition of variables.

Variables	Symbol	Units	Source
Harmonised Index of Consumer Prices	HICP	Index, 2015=100	Eurostat (2024)
Rate of unemployment	UNP	Percentage of population in the labour force	Eurostat (2024)
Industrial Production Index	IPI	Volume index of production Index, 2015=100	Eurostat (2024)
Nominal exchange rate	NER	EUR/USD	FRED, Federal Reserve Bank of St. Louis (2024)
Price of oil	OIL	Crude oil prices: Brent – Europe, dollars per barrel	FRED, Federal Reserve Bank of St. Louis (2024)
Global price of energy	GPEN	Global Price of Energy Index, Index 2016 = 100,	FRED, Federal Reserve Bank of St. Louis (2024)
Global Food Price Index	GPFI	Global price of Food index, Index 2016 = 100	FRED, Federal Reserve Bank of St. Louis (2024)
Global Supply Chain Pressure Index	GSCPI	This is a composite index that takes into account various factors such as port congestion, container availability, and customs clearance procedures.	Federal Reserve Bank of New York (2024)
Monetary aggregate	M3	Broad money	Eurostat (2024)

We also present descriptive statistics (see Table 2) for all the countries, and we additionally discuss the main trends in the evolution of the selected variables over time.

Table 2. Descriptive statistics

	HICP	UNP	IPI	NER	OIL	GPEN	GPFI	GSCPI	M3
Mean	98.265	8.4330	102.8	1.2442	75.577	107.2	173.1	0.1927	0.4218
Median	99.6	7.4	102.1	1.2306	71.14	103.51	160.64	-0.1	0.38
Maximum	158.08	28.1	213.4	1.5774	132.72	161.81	376.41	4.31	1.95
Minimum	62.52	1.7	51.3	0.9799	18.38	73.19	55.89	-1.64	-0.99
Std. Dev.	11.008	4.2573	16.287	0.1307	25.116	17.647	58.803	1.097	0.4098
Observations	5885	5886	5861	5859	5886	5886	5886	5886	5832

Source: Authors' calculations.

Summary statistics for all the variables used in the analysis, presented in Table 1, show considerable heterogeneity across countries and over time. For example, as measured by the Harmonised Index of Consumer Prices, average inflation in Europe is 98.2, with a minimum of 62.52 and a maximum of 158.08. The domestic output gap is on average 102.8. In addition, the variance of the unemployment indicates significant differences among European countries. With regard to energy and non-energy prices, energy prices exhibit more frequent fluctuations than non-energy prices, suggesting a potentially significant role for energy prices in explaining inflation developments in Europe. Although global supply-chain pressures appear to be relatively stable overall, the pandemic and the war in Ukraine have caused more volatile supply-chain disruptions.

4. METHODOLOGY

The existing literature reports a number of methodologies used to analyse determinants of inflation, including: a time series approach based on VAR models by Payne (2002); a structural VAR model by Jankov et al. (2008), Krznar and Kunovac (2010), and Globan et al. (2016); a Bayesian VAR by Jovičić and Kunovac (2017); and a model of the Phillips curve by Krznar (2011). Among the studies employing a dynamic panel model in the analysis of inflation determinants are Agayev (2012) and Deniz et al. (2016). In addition, recent studies have employed the ordinal probit model, as demonstrated by Dąbrowski et al. (2025).

Our empirical strategy is based on a panel data analysis. Before proceeding with the econometric method, we need to verify the stationarity of the variables selected. In this paper, we perform a panel analysis and apply panel unit root tests – the Im, Pesaran, and Shin (IPS) test (2003) and two alternatives of a Fisher-type test (the augmented Dickey–Fuller [ADF] and the Phillips–Perron [PP] tests), as outlined by Maddala and Wu (1999). These allow for the deterministic and dynamic effects differing across the panel members. In this paper, a 10% level of significance was applied as a critical value for determining whether the time series is stationary.

According to Baltagi (2001), Fisher-type tests have several advantages: (1) the cross-sectional dimension can be either finite or infinite; (2) each group can include both non-stochastic and stochastic components; and (3) the time-series dimension can vary across cross-sections. An additional advantage is that, unlike the IPS tests, Fisher-type tests do not require a balanced panel and allow for the use of different lag lengths in the individual ADF regressions. Although we prefer the Fisher-type tests, we also report the results of the IPS tests to provide an additional robustness check.

Furthermore, to estimate the existence of a long-run relationship between the dependent variable and the explanatory variables, we test the cointegration equations in the panel. We use two cointegration tests – Pedroni (1999) and Kao (1999) – to verify the null hypothesis of no cointegration between the selected determinants. Pedroni (1999) derives seven panel cointegration test statistics, of which four are based on the within-dimension and three are based on the between-dimension approach. Namely, the first of the simple panel cointegration statistics is a type of non-parametric variance ratio statistic. The second is a panel version of a non-parametric statistic that is analogous to the familiar Phillips and Perron rho-statistic. The third statistic is also non-parametric and is analogous to the Phillips and Perron *t*-statistic. The fourth statistic is a simple panel cointegration test corresponding to the augmented Dickey–Fuller *t*-statistic (Pedroni, 1999). The rest of the statistics are based on a group mean approach. Namely, the first of the simple panel cointegration tests represents a non-parametric variance ratio approach. The second extends this by providing a panel-based version of a non-parametric test comparable to the well-known Phillips–Perron rho-statistic. Similarly, the third test is non-parametric and aligns with the logic of the Phillips–Perron *t*-statistic. The fourth is structured as a panel cointegration test, similar to the augmented Dickey–Fuller *t*-statistic (Pedroni, 1999). The remaining tests are derived using a group mean framework. Furthermore, in our empirical analysis, we use additional cointegration tests, such as the Kao (1999) test, which is based on the Engle-Granger two-step procedure and imposes homogeneity on the members in the panel. The null hypothesis of no cointegration is tested using an ADF-type test.

Having established the cointegration tests, the next step is to estimate the long-term relationship between the variables. The literature proposes different estimation methods for panel cointegration models. In this paper, we use the FMOLS and the DOLS estimators. We choose these methods for several reasons. Firstly, the OLS estimator is a biased and inconsistent estimator when applied to a cointegrated panel. On the other hand, DOLS and FMOLS take care of both small-sample bias and endogeneity bias by taking the leads and lags of the first-differenced regressors (Kao & Chiang, 2001). Secondly, for panels that have a larger time dimension (*T*), the dynamic estimator of the generalised method of moments (GMM) is not very effective as it is more applicable when the number of the cross-sectional units is higher than the time periods (Roodman, 2009). In this study, the time dimension (T=218) is much greater than the cross-sectional dimension (N=27). Thirdly, these estimators allow for a greater flexibility in the presence of heterogeneity in the examined cointegrated vectors (Pedroni, 1999, 2001).

However, the DOLS parametric approach is preferred to the FMOLS non-parametric approach because the latter imposes additional requirements of all variables being integrated of the same order I(1) and the regressors themselves not being cointegrated (Masih & Masih, 1996). Additionally, according to Kao and Chiang (2000), the FMOLS estimator is complicated by the dependence of the correction terms upon the preliminary estimator, which may be very biased in finite samples with panel data. The DOLS estimator also has the additional advantage of controlling the endogeneity in the model, as augmentation of the lead and lagged differences of the regressor suppresses the endogenous feedback (Lean & Smyth, 2010). This indicates that the DOLS estimator may be more promising than the OLS or FMOLS in estimating cointegrated panel regressions.

With a view to explaining the idea of the FMOLS estimator, we refer to the following fixed-effects model:

$$CMD_{i,t} = \alpha_i + x'_{i,t}\,\beta + u_{i,t}\,, \tag{1}$$

where i (=1, 2,…, N) and t (=1, 2, ..., T) index the cross-sectional units and time series units, respectively, $CMD_{i,t}$ is the dependent variable, β is the vector of parameters, α_i are intercepts and $u_{i,t}$ are the stationary disturbance terms. Here, $x_{i,t}$ is assumed to be the matrix of explanatory variables, which are I(1) for all cross-section units. It is assumed that it follows an autoregressive process in the following form:

$$x_{i,t} = x_{i,t-1} + \varepsilon_{i,t}\,, \tag{2}$$

with an innovation vector: $w_{i,t} = (u_{i,t}, \varepsilon_{i,t})$.

Given that $w_{i,t} = (u_{i,t}, \varepsilon_{i,t})$ ~ *I(0)*, the variables are said to be cointegrated for each member of the panel with the cointegrating vector β. The asymptotic distribution of the OLS estimator is the condition for the long-run covariance matrix of the innovation vector. The FMOLS estimator is derived by making an endogeneity correction (by modifying the variable $CMD_{i,t}$) and a serial correlation correction (by modifying the long-run covariance of the innovation vector, $w_{i,t}$). The resulting final estimator is expressed as follows:

$$\beta_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x})(x_{it}-\overline{x}_i)'\right]^{-1} * \left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it}-\overline{x})\hat{CMD}_{it} - T\hat{\Delta}_{\varepsilon U}\right)\right]^{-1} \tag{3}$$

The DOLS estimator has been extended to panel analysis by Kao and Chiang (2001), who developed finite sample properties of the OLS, DOLS, and Pedroni's FMOLS. The DOLS estimator in a panel case environment is obtained by running the following regression:

$$CMD_{i,t} = \alpha_i + \beta_i x_{i,t} + \sum_{k=-p_1}^{p_2}\delta_k \Delta CMD_{i,t-k} + \sum_{k-q_1}^{q_2}\lambda_k \Delta x_{i,t-k} + u_{i,t} \tag{4}$$

where p and q denote the numbers of leads and lags typically chosen using certain information criterion (e.g., Akaike, Hansen).

Based on all the above, our further analysis will evaluate the results of the FMOLS and DOLS estimations.

5. EMPIRICAL RESULTS

In this section, we present the results of the econometric analysis of the determinants of inflation in the 27 EU member states.

The first step of our empirical analysis is to perform panel unit root tests (Table 3). As already mentioned in the previous section, we applied panel-IPS unit root tests and Fisher-type tests using the ADF and PP tests, as outlined by Maddala and Wu (1999).

These tests are conducted on both levels and first differences for all variables in the models. Bearing in mind the traditional null hypothesis of stationarity, the results indicate acceptance of stationarity at first difference and rejection of stationarity at levels, indicating that all series are *I(1)*.

Table 3. Panel unit root tests

	Im, Pesaran, and Shin W-stat		ADF-Fisher Chi-square		PP-Fisher Chi-square		Conclusion
Variables	At a level of	First differentiation	At a level of	First differentiation	At a level of	First differentiation	
HICP	11.4218	-46.5466***	5.08447	1429.75***	25.8044	1824.11***	I(1)
UNP	-0.96296	-25.0091***	72.7023	807.858***	47.1114	1983.40***	I(1)
IPI	0.50807	-35.6466***	56.9720	1223.35***	103.885***	2884.68***	I(1)
NER	-1.56792	-26.8533***	49.5211	809.875***	51.3039	3025.20***	I(1)
OIL	-0.71539	-7.87456***	35.9627	155.868***	45.3927	165.254***	I(1)
GPEN	-2.98800***	-29.0025***	67.4391	906.665***	66.4362	1850.52***	I(1)
GPFI	-0.42973	-4.23847***	45.4030	793.296***	62.2152	115.717***	I(1)
GSCPI	0.49281	-6.69124***	41.6270	131.660***	44.5629	140.391***	I(1)
M3	-0.56225	-4.17612***	37.4717	83.4418***	977.966***	1110.43***	I(1)

Note: *, ** and, *** indicate that the test statistic is significant at the 10%, 5%, or 1% level, respectively.
Source: Authors' calculations.

Following the panel unit root tests results for all series of interest, the null hypothesis of a unit root cannot be rejected. Since the null hypothesis of a unit root holds for all series of interest, we continued with panel cointegration tests as the next step.

Table 4. Results of the panel cointegration tests of Pedroni and Kao

Statistics	New EU member countries (NMS - 11)
Panel v-statistic	-2.749116
Panel rho-statistic	-105.3884
Panel PP-statistic	-130.9643
Panel ADF-statistic	-64.5233
Group rho-statistic	-111.264
Group PP-statistic	-145.146
Group ADF-statistic	-63.3234
Kao residual cointegration test (*p*-value)	0.000

Note: *, **, and *** indicate that the test statistic is significant at the 10%, 5%, or 1% level, respectively.
Source: Authors' calculations.

As presented in Table 4 the majority of Pedroni's (1999, 2001) tests indicate that there is a cointegration relationship in all models. Kao's (1999) test in Table 4 also indicates a cointegration relationship in all models.

Keeping in mind that all the determinants in all the models are co-integrated, in the next step we test long-run linkage among the inflation and other selected determinants using the FMOLS and DOLS tests. The results are presented in Table 5 below.

Table 5 Empirical results

Variable	FMOLS	DOLS
LUNP	-0.018 (0.004)	-0.021 (0.005)
LIPI	0.105*** (0.011)	0.101*** (0.012)
LEURUSA	-0.021 (0.018)	-0.023** (0.022)
LOIL	0.084** (0.015)	0.125*** (0.020)
LFI	0.053 (0.013)	0.045*** (0.007)
LEN	0.161*** (0.015)	0.197** (0.022)
GSCPI	0.024** (0.005)	0.049** (0.006)
M3	0.028 (0.003)	0.050 (0.004)
DUMMY	0.034*** (0.010)	0.079*** (0.012)
Adjusted *R*-squared	0.71	0.87
Observations	5751	5736

Notes: *, **, and *** indicate that the test statistic is significant at the 10%, 5% or 1% level, respectively.
Standard errors in parentheses.
Source: Authors' calculations.

The findings of this study highlight the multifaceted determinants of inflation in EU countries, emphasising the roles of industrial production, energy prices, currency valuation, and external shocks. Our results align with existing literature, reinforcing the complex interplay between supply and demand-side factors in shaping inflation dynamics.

1. Industrial production and inflationary pressures

The industrial production index significantly impacts inflation, a trend that can be attributed to several mechanisms:

- Production costs and pass-through effects: Rising producer prices (Producer Price Index [PPI]), driven by higher raw material, energy, and labour costs, directly feed into consumer inflation. Energy prices in the EU surged by 92.9% in May 2022 compared to the previous year, while non-energy industrial products increased by 16.0%. Countries such as Denmark (+59.8%), Romania (+59.2%), and Belgium (+52.6%) experienced the highest price increases, whereas Ireland (+24.2%) and Slovenia (+25.7%) saw more moderate growth.
- Post-pandemic demand recovery: The inflationary effects of industrial production were amplified in the post-COVID recovery phase, as pent-up consumer demand and supply-side bottlenecks placed upward pressure on prices.
- Currency depreciation: Changes in PPI influence currency values, affecting import prices and further fuelling inflation. The euro's depreciation in 2022, driven by the slower rate hikes of the ECB compared to the Fed, increased imported inflation. On average, euro depreciation added 0.36 percentage points to inflation per month in 2022.

2. Energy prices as a key inflationary driver

Our analysis confirms that energy price fluctuations exert a profound influence on inflation:

- Oil price transmission mechanism: A 1% increase in oil prices raises inflation by 0.84% (FMOLS method) and 0.125% (DOLS method), underlining oil's pivotal role in EU inflation dynamics. The war in Ukraine intensified oil price volatility, particularly affecting diesel and gasoline costs.
- Electricity and natural gas prices: EU electricity prices are linked to natural gas prices via the merit order system, causing energy shocks to disproportionately impact inflation. A 1% rise in global energy prices leads to inflation increasing by 0.161% to 0.197%, depending on the estimation method.
- Government interventions and policy effectiveness: To curb inflation, some governments introduced fuel subsidies and tax reductions (e.g., France, Germany, and Poland). However, due to persistent energy dependency on Russian oil and gas, inflationary pressures remain significant.

These results are consistent with previous studies (Aziz & Dahalan, 2015; Masso & Staehr, 2005) which confirm the systemic impact of oil price shocks on inflation. LeBlanc & Chinn (2004) and Cunado and Perez de Gracia (2005) further emphasise nonlinear and long-term effects of oil price fluctuations, reinforcing the need for adaptive policy responses.

3. Food price inflation and supply chain disruptions

Our findings also indicate that food price inflation plays a notable role in overall inflation trends, with a 1% increase in food prices raising inflation by 0.045% on average.

- Supply chain vulnerabilities: The Ukraine war disrupted global grain and staple exports, leading to record-high food prices. While the EU's Common Agricultural Policy (CAP) ensures food security, reduced imports of Ukrainian grain have increased production costs, particularly for livestock feed and processed food.
- Social and economic consequences: Rising food prices have disproportionate effects on lower-income households and increase the burden on government social protection programmes. The need for targeted fiscal responses to support vulnerable groups becomes essential in mitigating the socio-economic fallout.

These findings align with Sek et al. (2015), who emphasise the heightened sensitivity of inflation to global food and energy price shocks, particularly in economies with weaker financial stability.

4. Policy implications

Given the complexity of inflationary drivers, a coordinated policy approach is essential for stabilising inflation in the EU:

- Monetary policy adjustments: The ECB's monetary policy needs to strike a balance between inflation control and economic stability. While interest rate hikes can curb demand-driven inflation, they may have limited effects on supply-side inflation stemming from energy shocks. A gradual and data-driven tightening strategy could mitigate unintended economic slowdowns.

- Energy market reforms and diversification: To reduce vulnerability to energy price shocks, the EU must accelerate the transition to renewable energy sources and diversify energy imports. Strengthening strategic reserves and improving energy efficiency will help moderate inflationary pressures in the long run.
- Targeted fiscal policies: Rather than broad subsidies, targeted support measures for lower-income households and energy-intensive industries would help cushion inflation's regressive effects without fuelling excess demand.
- Supply chain resilience strategies: Strengthening EU-wide logistics networks, enhancing local production capacity, and reducing external dependencies on food and raw materials can improve economic resilience against global supply shocks.

Inflation in the EU is driven by a combination of rising industrial and energy costs, currency fluctuations, and external shocks. Our findings highlight the nonlinear and persistent nature of inflationary pressures, emphasising the need for coordinated monetary and fiscal policies. Given the ongoing uncertainties, policymakers should prioritise energy diversification, adaptive monetary strategies, and targeted fiscal interventions to mitigate inflation risks and enhance economic stability.

6. CONCLUSION

This analysis of the inflationary process, based on variations in relative prices, reveals key insights into the factors driving inflation in the European Union. Initially, cost-push factors were the dominant drivers of inflation largely due to sharp increases in energy prices. However, this effect gradually weakened as crude oil price growth slowed compared to the same period in the previous year. By October 2021, there was a noticeable shift, with aggregate demand (demand-pull) playing a more significant role in driving inflation. This demand contribution to inflation remained relatively stable, around two percentage points, until March 2022. In the months following, approximately one percentage point of inflation remained unexplained, suggesting the possibility of inflationary expectations playing a role. However, proving the influence of inflationary expectations remains challenging, and alternative explanations, such as relative price variations, supply chain disruptions, and the geopolitical impact of the Russian invasion of Ukraine, provide plausible contributing factors.

One of the novel aspects of this study is the examination of the divergent reactions of EU member states to the external energy price shock. The analysis shows significant heterogeneity in inflation outcomes across euro area countries. This divergence began as early as 2020, when the pandemic induced disinflationary pressures in tourism-dependent countries. As the pandemic receded, inflationary pressures mounted most notably in countries with a more resilient economy and labour shortages. The Baltic states were disproportionately affected by the war and sanctions, which disrupted supply chains and halted imports from Russia. Prior to the war, gas and electricity were relatively cheaper in the Baltic states compared to the broader euro area, amplifying the percentage increases in energy prices. Differences in energy generation mixes and household utility contracts also contributed to the varied inflation experiences across countries. In some countries, where utility prices were fixed for longer periods, inflationary effects were delayed.

The results of this study highlight an important consideration for monetary policy in the euro area. If central bankers focus too heavily on the role of aggregate demand and overlook the persistent influence of energy prices and relative price variations, there is a risk of tightening monetary policy prematurely. Overly aggressive interest rate hikes could unnecessarily slow down economic growth or even trigger a recession, potentially exacerbating inflationary pressures. The transition to a new definition of target inflation, based on medium-term forecasts, further complicates the ability to respond to inflationary shocks accurately. This analysis underscores the challenges of forecasting inflation in the face of multiple external shocks, such as the pandemic and the war in Ukraine, which reduce the effectiveness of traditional inflation models.

In comparison to the existing literature, this study offers additional insights by emphasising the continued importance of energy price shocks in driving inflation, even as demand-pull factors begin to play a more substantial role. The literature often focuses on the interplay between demand and supply-side factors, but this paper provides a clearer picture of how geopolitical and global supply chain disruptions exacerbate inflation in an interconnected economic environment. While previous studies have explored the impact of oil prices and supply chain disruptions, the specific effects observed in the EU during the pandemic and the war in Ukraine suggest that these factors have a more profound and complex influence on inflation than has traditionally been acknowledged. Thus, the findings challenge the conventional understanding of inflation dynamics and underscore the need for more nuanced monetary and fiscal policies that account for the evolving nature of inflation drivers in the current global context.

In conclusion, while inflation in the EU has been largely driven by external shocks, the interaction between demand-pull factors, energy prices, and supply chain disruptions underscores the complexity of managing inflation. The findings suggest that monetary policy should be cautious in responding to inflationary pressures, recognising the dominant role of energy prices and the uncertainty surrounding inflationary expectations. Future monetary policy should focus on a more balanced approach, taking into account the varied impacts of external shocks and the nuanced dynamics of inflation across different EU member states.

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