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Examining Impact of Inflation and Inflation Volatility on Economic Growth: Evidence from European Union Economies

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Abstract: Examining the economies of the European Union from 2000 to 2023, we have found no strong evidence that the inflation rate has a negative impact on economic growth. In contrast, in line with conventional economic theory, higher interest rates are associated with lower economic growth. The results remain consistent even after controlling for various control variables, non-linearities and endogeneity issues. These findings suggest that an aggressive tightening of monetary policy in the euro area, aimed at rapidly bringing inflation under control, could actually be detrimental to economic growth. Since the negative effects of monetary tightening on growth are clear, while the benefits of rapidly reducing inflation on economic growth are ambiguous, the European Central Bank must be cautious about both the intensity and the duration of monetary tightening.

Keywords: economic growth; inflation; inflation volatility; interest rates; European Union; panel data

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1. Introduction

The recent inflationary episode in the European Union compelled the European Central Bank (ECB) to significantly tighten its monetary policy, to counteract inflationary pressures. Over a fourteen-month period, from July 2022 to September 2023, the ECB increased its key interest rates by 450 basis points. This aggressive monetary tightening raises concerns about its potential adverse impact on economic growth, given that higher interest rates tend to negatively influence investments and consumption.

Conversely, a relatively high inflation rate may adversely affect economic activity. Apart from the inflation rate, economic activity may be negatively influenced by inflation volatility, as highlighted by Friedman (1977). In this respect, as far as monetary policy is concerned, the ECB is confronted with a dilemma, given that both high interest rates and inflation or inflation volatility have the potential to hinder economic growth.

This study presents evidence regarding the relationship between inflation rate, inflation volatility, and growth in EU economies from 2000 to 2023. In addition, this study focuses on the effects of high interest rates on economic growth in Europe. The econometric results suggest that when focusing exclusively on economic growth, there is no trade-off in the ECB's policy choices. We find no statistically significant evidence indicating that the inflation rate affected growth in European economies during the period 2000–2023. However, some evidence that inflation volatility negatively affects growth exists. Furthermore, higher

interest rates are strongly related to lower real gross domestic product (GDP) growth for European economies during the aforementioned period.

This study makes two significant contributions to the existing literature. First, it sheds light on an area that has not yet been extensively investigated: the nexus between inflation rate and inflation volatility with real gross domestic product (GDP) growth in European Union economies after the establishment of the ECB. Second, this study contributes to the ongoing debate regarding the level of ECB interest rates. In the current circumstances where the ECB is confronted with the dilemma of either maintaining high interest rates or reducing them, it is crucial to consider, as per the findings of this study, that while high interest rates harm economic growth, the inflation rate does not seem to significantly affect real economic activity. Therefore, a growth-friendly policy should align with a trajectory of lower interest rates.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature. Section 3 provides an overview of the variables, data, and econometric methodology employed in this study. Section 4 presents the empirical findings derived from both linear and non-linear panel data models. Section 5 explores the robustness of the primary findings, conducting a series of rigorous robustness tests. Finally, Section 6 concludes the paper.

2. Literature Review

2.1. Early Studies on Relationship Between Inflation and Growth

The relationship between inflation and economic growth has been extensively investigated for decades, beginning in the 1960s[1]. After the 1980s, interest in this relationship was rekindled, leading to the publication of a significant number of research papers attempting to explore whether inflation and growth are directly or inversely associated. Fischer (1993) finds evidence that inflation may harm growth by reducing investment and the rate of productivity growth. Nevertheless, these results are valid only for very high inflation episodes. However, the study does not find evidence that low inflation is a clear-cut path for high growth, even over long periods. Barro (1996) provides evidence of a negative relationship between inflation and growth through a channel of lower investments. However, these results hold for high inflation experiences, and the magnitudes of the adverse effects on growth are quite mild. Bruno (1995) and Bruno and Easterly (1996, 1998) also investigate the relationship between growth and inflation. Their findings suggest that this relationship turns negative only when high-frequency data are examined, and specifically, only when the inflation rate surpasses a particular threshold, which they propose to be 40% annually. The main finding in the aforementioned studies is that they reveal the negative effects of inflation on growth, particularly at high inflation rates and notably well beyond a double-digit range. All these findings can be summed up by Rogoff's (2003, p. 79) phrase that inflation surpassing the 40 percent mark can be deemed acutely damaging. It should be noted that a significant amount of research was conducted during the 1990s, such as those by Levine and Renelt (1992), Levine and Zervos (1993), and Sala-I-Martin (1997a), which failed to establish a robust relationship between inflation and economic growth.

However, during the same period, another series of studies highlighted the potential negative impact of inflation rates on growth, even at lower levels. Using a panel of 23 industrial countries, Burdekin et al. (1994) estimated that a swift shift from zero inflation to 10% inflation could reduce the growth rate by one to two percentage points. Sarel (1995) lowered this threshold to 8%. By examining 87 economies during the period 1970–1990, it was concluded that the relationship between inflation and economic growth is non-linear. He finds that when inflation is low (below 8%), the effect on growth is not significantly negative; in fact, it may even be slightly positive. However, above the structural break of

the 8% annual inflation rate, the effect becomes negative. Gylfason and Herbertsson (2001), employing panel regressions for 170 countries from 1960 to 1992, identified a threshold at which inflation rates exceeding 10% to 20% per year generally have an adverse impact on economic growth. Beyond this threshold, the effect of inflation on growth becomes negative. Furthermore, Ghosh and Phillips (1998) further reduced this threshold to 5%, arguing that the moderate or intermediate inflation range—perhaps 5–30 percent per year—negatively affects economic growth.

2.2. Inflation and Growth: More Recent Empirical Evidence

In more recent empirical studies, there have been thresholds above which inflation has a negative impact on economic growth. Arawatari et al. (2018) find that when inflation exceeds a threshold level of 15–20%, a sharp decline in the long-run growth rate of income is observed. Similarly, He (2023) identifies a zero marginal effect on growth at 5% inflation using ordinary least squares (OLS) estimation and at 3% using instrumental variables (IVs) estimation.

Moreover, the inflation threshold varies according to the group of countries analyzed. Burdekin et al. (2004) criticize the grouping of industrial and developing economies when examining the relationship between inflation and growth, suggesting that it may lead to unreliable results. Their paper concludes that the threshold where inflation becomes harmful for growth is lower than 20–40%; using a linear specification, they found a higher threshold for industrial countries (8%) than for developing countries (3%). Furthermore, Eggoh and Khan (2014) confirm the sensitivity of the relationship between inflation and growth to the choice of country groups. They find a threshold of 12.4% annual inflation for the global set of 102 developing and developed economies. However, this threshold varied among different groups of economies: 3.4% for advanced economies, 10% for upper-middle-income economies, 12% for middle-income economies, and approximately 20% for low-income economies. Similarly, Espinoza et al. (2010) placed a threshold above 10% for developing countries after examining a panel of 165 countries and data for 1960–2007. For advanced economies, the threshold is found to be much lower. Ghossoub (2023) also identifies a threshold where the correlation between inflation and economic growth becomes negative. This threshold is higher for developing economies compared to advanced ones, due to more concentrated banking systems and higher regulation in developing countries.

The existence of a threshold means that inflation below a certain turning point may be beneficial for economic growth. Using over 100 years of U.S. data, Ahmed and Rogers (2000) find that the effects of relatively low inflation on output are positive. Pollin and Zhu (2006), analyzing a set of 80 countries between 1961 and 2000, observed that higher inflation is associated with moderate gains in gross domestic product (GDP) growth up to a threshold of approximately 15–18%. Recently, Zhou (2019) proposed a theoretical explanation of a potential channel through which moderate inflation could have a positive effect on economic growth through investment. In this regard, inflation may have a positive effect on growth by reducing the liquidity risk of investment projects. In addition, Huang et al. (2021) explain that inflation can have a positive effect on growth if variety-expanding R&D (entry) is subject to a cash-in-advance (CIA) constraint. A CIA constraint requires cash to be available before certain activities, such as consumption, production, or R&D investment, can take place. This constraint affects how inflation influences economic growth, as described in the Schumpeterian growth model. Furthermore, Yilmazkuday (2021) finds that inflation may result in higher long-run growth especially in countries with weaker institutions. When these countries have limited access to direct capital (like

investments from private sectors or foreign investors), increasing the money supply can act as a substitute and boost real investment in the economy.

2.3. Inflation Volatility and Growth

In addition to the inflation rate, inflation volatility was examined for its potential adverse effects on growth. As mentioned in the Introduction, Friedman (1977) stressed that inflation volatility, rather than inflation rate, adversely affects economic growth. Inflation volatility could detrimentally affect economic activity by increasing the recorded rate of unemployment. Empirical research has explored these theoretical arguments. Judson and Orphanides (1999) examined a panel of 119 countries over the period 1959–1992 and concluded that inflation volatility was robustly and significantly negatively correlated with income growth across inflation levels and country type. Apergis (2005) investigated the impact of inflation uncertainty on the growth of OECD countries from 1969 to 1999 and found that the effects are negative. Accordingly, Fountas et al. (2006) confirmed the detrimental effect of inflation on real growth through the nominal uncertainty channel for G7 countries. Friedman's (1977) hypothesis was recently validated by Živkov et al. (2020), who discovered a negative impact of inflation uncertainty on gross domestic product (GDP) growth in eight Central and Eastern European countries.

2.4. Inflation and Growth in European Union Economies

This current literature review provides broad findings. First, it is often observed that there is a relatively high threshold, typically above two digits in inflation rates, where inflation turns negative for growth when grouping economies with different characteristics, such as developing and developed countries. Second, the formation of groups with similar economic characteristics may have contributed to more robust and conclusive results. Third, inflation volatility, and not just a high inflation rate, may have detrimental effects on economic growth.

Therefore, focusing on EU economies may yield more robust findings regarding the nexus between inflation, inflation volatility, and growth within a group of countries sharing similar economic characteristics, steering clear hyperinflation observations[2] and operating under the same central bank's monetary policy[3].

To the best of our knowledge, the literature on inflation, inflation volatility, and growth exclusively focused on European countries is relatively scarce. Pintilescu et al. (2014) examined ten European emerging economies for the period 1990 to 2013, aiming to investigate the impact of inflation uncertainty on output growth. Their research has revealed only a few significant causal relationships. Specifically, a relationship between inflation volatility and output growth was identified in only two of the ten countries. Cuaresma and Silgoner (2014) examined the impact of inflation on growth for a panel of 14 European Union countries, specifically from 1960 to 1999, in the years preceding monetary unification. Their results validated the hypothesis that the relationship between inflation and growth is positive for very low inflation, insignificant thereafter, and negative for high two digit inflation. More recently, Živkov et al. (2020) discovered that inflation in eight Central and Eastern European countries has an indirect impact on gross domestic product (GDP) growth via inflation uncertainty.

3. Methodology and Data Set

3.1. Linear Specification

The growth regression equation with country fixed effects and year dummies is as follows:

$$G_{j,t} = \beta_1 \times Y_{j,t} + \beta_2 \times Z_{j,t} + \beta_3 \times V_{j,t} + \beta_4 \times X_{j,t} + \delta_j + \gamma_t + \varepsilon_{j,t} \quad (1)$$

where $Y_{j,t}$ is a vector of variables that always appear in the regressions based on the standard growth literature (Levine & Renelt, 1992; Levine & Zervos, 1993; Barro, 1991, 1996; Sala-I-Martin, 1997a, 1997b; Reinhart & Rogoff, 2010): (i) trade openness, measured as the ratio of imports plus exports to gross domestic product (XM); (ii) investment, measured as the ratio of gross fixed capital formation to gross domestic product (Inv); and (iii) public debt to gross domestic product (Debt) as a fiscal policy indicator.

Furthermore, Zj,t is the first variable of interest, the inflation rate, measured by the annual rate of change in the Harmonized Index Of Consumer Prices (HICP); and Vj,t is the second variable of interest and inflation rate volatility. Inflation rate volatility is measured in two ways. First, it is measured as the moving averages of the standard deviation of year-on-year inflation rates over three-year periods (HICP_V) (Hafer, 1986; Davis & Kanago, 2000; Blanchard & Simon, 2001). To capture the extent of possible short-term fluctuations in inflation, an alternative measure is also considered: the moving average of the standard deviation of monthly intra-year inflation (HICP_V_alt) (Judson & Orphanides, 1999)[4].

In addition, $X_{j,t}$ represents a vector that includes one additional control variable selected from a pool of N variables, which are also considered in the growth literature. The pool consists of the following variables: (i) monetary conditions (King & Watson, 1996; Arestis & Demetriades, 1997) proxied by long-term interest rates and specifically the average annual yield of 10-year government bonds (LTIR); (ii) credit expansion (King & Levine, 1993; De Gregorio & Guidotti, 1995; Sala-I-Martin, 1997a, 1997b) (Credit) proxied by the total credit to the private non-financial sector as an annual rate of change; (iii) the size of the government (Barro, 1996, 2003; Burdekin et al., 2004) measured by the total expenditures of the general government as a percentage of gross domestic product (GG); (iv) expenditures on research and development activities for both the private and public sectors as a share of gross domestic product (R&D) (Zachariadis, 2004; Pessoa, 2010); (v) a measure of education (Barro, 1991, 1996; Bils & Klenow, 2000), which is the upper secondary and post-secondary non-tertiary education as a percentage of total population, from 15 to 64 years (EDU); and (vi) an index measuring the quality of institutions (Hall & Jones, 1999; Barro, 1996, 2003; Rodrik et al., 2004) (Institutions), which is the sum of the scores of the six governance indicators of the World Bank.

It should be noted that the choice of control is guided by specific considerations. The purpose here is not to present an exhaustive account of the determinants of growth, but rather to isolate the effects of inflation and inflation volatility on economic growth. The adoption of a parsimonious specification that accounts for unobservable heterogeneity may be sufficient to satisfactorily address the central research question.

The dependent variable, $G_{j,t}$, is the annual rate of change (percentage) in real gross domestic product (GDP) per capita. δ_i are country fixed effects that account for cross-sectional unobserved heterogeneity, γ_t are time fixed effects[5] to capture aggregate time shocks, and $\varepsilon_{i,t}$ is the idiosyncratic error term.

The research covers the period from 2000 to 2023 using annual data with unbalanced panels. The data set is primarily sourced from the EUROSTAT database, with the exception of the credit expansion variable (Credit), obtained from the Federal Reserve Bank of Saint

Louis, and the quality of institutions variable (Institutions), sourced from the World Bank's Worldwide Governance Indicators (see Table A1 in Appendix A).

3.2. Non-Linear Specifications

To capture the potential non-linearities between the relationship of inflation, inflation volatility, and growth, two alternative specifications are employed. First, following Pollin and Zhu (2006), a squared term of the inflation rate is introduced in the model (Z^2j,t).

$$G_{j,t} = \beta_1 \times Y_{j,t} + \beta_2 \times Z_{j,t} + \beta_3 \times Z\ Squared_{j,t} + \beta_4 \times V_{j,t} + \beta_5 \times X_{j,t} + \delta_j + \gamma_t + \varepsilon_{j,t} \quad (2)$$

Introducing non-linearity into the model by including the squared inflation rate allowed the regression equation to be estimated as a second-degree polynomial. This approach captures changes in slopes that are dependent on variations in the independent variable. Consequently, the slope of the estimating equation can vary in response to fluctuations in the inflation rate, facilitating the identification of turning points in the relationship between the inflation rate and economic growth.

Second, the interaction between the inflation rate and inflation volatility is examined by modifying the baseline model by introducing the interaction term $(\beta_4 \times Z_{j,t} \times V_{j,t})$.

$$G_{j,t} = \beta_1 \times Y_{j,t} + \beta_2 \times Z_{j,t} + \beta_3 \times V_{j,t} + \beta_4 \times Z_{j,t} \times V_{j,t} + \beta_5 \times X_{j,t} + \delta_j + \gamma_t + \varepsilon_{j,t} \quad (3)$$

The rationale for including the interaction term is that individually relatively high inflation and inflation volatility may not significantly affect real output. However, when combined, inflation and inflation volatility may increase the impact on the economy. A positive (negative) and statistically significant coefficient β_4 indicates that the combination of inflation rate and inflation volatility amplifies (dampens) the effect of inflation and inflation volatility on economic growth.

4. Results

Table 1 provides the preliminary results concerning the relationship between inflation, inflation volatility, and economic growth. Concerning the impact of the inflation rate on gross domestic product (GDP) growth, no statistically significant findings were observed. Similarly, there is no evidence of a significant relationship between inflation volatility and growth across the various specifications. Notably, in only 1 out of 14 cases, when credit growth is introduced as an additional control variable, the volatility of inflation (measured as the standard deviation of year-on-year inflation rates over a three-year period, –HICP_V) is found to be negatively and significantly (at the 10% significance level) associated with gross domestic product growth in European economies.

While these linear specifications may not be theoretically the most preferred, they demonstrate the isolated effects of inflation rate, inflation volatility, and other control variables on growth before addressing non-linearity issues. Additionally, control variables such as investments and trade openness, which are standard in the growth literature, are consistently found to have a positive and statistically significant effect on gross domestic product growth. Interestingly, the debt-to-GDP ratio is also positively associated with gross domestic product growth, suggesting that during the period 2000–2023, growth coincided with public debt accumulation and did not hinder EU economies from expanding. Regarding the remaining control variables, long-term interest rates (LTIRs) and general government expenditures (GG) were both negatively associated with gross domestic product growth. In contrast, the level of education (EDU) was found to be positively related to gross domestic product growth.

Table 1. Baseline model results.

Dependent: GDP_C	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Constant	−3.903 *	−3.668	0.835	0.973	−4.811 *	−4.971 *	7.63 ***	8.36	−4.755 *	−4.506 *	−11.137 ***	−10.998 ***	−3.328	−3.15
	(1.971)	(2.175)	(1.85)	(1.86)	(2.582)	(2.817)	(2.216)	(2.322)	(2.443)	(2.587)	(2.586)	(2.773)	(2.024)	(2.193)
HICP	−0.1	−0.139	−0. 098	−0.137	−0.116	−0.137	−0.097	−0.116	−0.108	−0.153	−0.071	−0.099	−0.097	−0.136
	(0.084)	(0.104)	(0.093)	(0.119)	(0.091)	(0.105)	(0.079)	(0.093)	(0.09)	(0.107)	(0.084)	(0.098)	(0.083)	(0.102)
HICP_V	−0.333		−0. 338		−0.548 *		−0.259		−0.358		−0.306		−0.336	
	(0.255)		(0.245)		(0.269)		(0.224)		(0.259)		(0.248)		(0.083)	
HICP_V_alt		−0.934		−0.233		−0.781		−0.976		−0.901		−1.063		−0.9348
		(0.828)		(0.729)		(0.926)		(0.764)		(0.80)		(0.711)		(0.821)
Inv	0.216 ***	0.227 ***	0.195 ***	0.200 ***	0.225 **	0.23 **	0.18 **	0.186 **	0.219 **	0.231 **	0.206 ***	0.215 ***	0.216 ***	0.226 **
	(0.065)	(0.072)	(0.062)	(0.066)	(0.089)	(0.092)	(0.071)	(0.01)	(0.08)	(0.086)	(0.064)	(0.07)	(0.065)	(0.072)
XM	0.032 **	0.029 **	0.021 *	0.019 *	0.034 **	0.033 **	0.021 **	0.018 *	0.033 **	0.03 **	0.035 ***	0.032 ***	0.032 **	0.03 **
	(0.012)	(0.012)	(0.011)	(0.011)	(0.016)	(0.016)	(0.01)	(0.010)	(0.012)	(0.011)	(0.01)	(0.009)	(0.012)	(0.012)
Debt	0.022 *	0.019 *	0.037 ***	0. 035 ***	0.023 **	0.02 **	0.040 ***	0.038 ***	0.023 *	0.019	0.015	0.013	0.021 *	0.018 *
	(0.012)	(0.01)	(0.012)	(0.011)	(0.01)	(0.009)	(0.011)	(0.01)	(0.013)	(0.011)	(0.012)	(0.011)	(0.011)	(0.01)
LTIRs			−0.553 ***	−0.588 ***										
			(0.187)	(0.093)										
Credit					0.034	0.033								
					(0.022)	(0.016)								
GG							−0.239 ***	−0.248 ***						
							(0.042)	(0.046)						
R&D									0.677	0.604				
									(0.792)	(0.791)				
Edu											0.158 ***	0.161 ***		
											(0.039)	(0.041)		
Institutions													0.09	−0.082
													(0.156)	(0.147)
Observations	643	643	627	627	541	541	643	643	632	632	637	637	643	643
Countries	27	27	27	27	24	24	27	27	27	27	27	27	27	27
R-squared	0.613	0.610	0.653	0.650	0.629	0.621	0.639	0.639	0.621	0.617	0.633	0.631	0.614	0.610
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the estimation results for the baseline model described in Equation (1). Robust standard errors are reported in the parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% levels, respectively.

Table 2 presents the results of the non-linear models (Equations (2) and (3)). Given that one of the primary objectives of this study is to center on the European Central Bank's policy regarding inflation and considering that long-term interest rates were found to be significant in the linear specifications, we exclusively included this variable as an additional control variable, alongside the other three standard control variables (investments, trade openness, and public debt to gross domestic product ratio)[6]. The inflation rate remains a statistically insignificant determinant of growth even when its quadratic term is introduced into the model. The same holds true for the two alternative inflation volatility variables. When exploring the potential interaction between inflation and inflation volatility in the first case, no significant difference was observed. Interestingly, when delving into the interaction between inflation and intra-year inflation volatility, both variables were not found to be significantly associated with growth.

Table 2. Non-linear model results.

Dependent: GDP_C	**(1)**	**(2)**	**(3)**	**(4)**
Constant	0.591	0.513	0.571	−0.455
	(1.909)	(1.959)	(1.821)	(1.922)
HICP	−0.019	−0.019	0.017	0.022
	(0.154)	(0.166)	(0.106)	(0.167)
HICP^2	−0.006	−0.011		
	(0.007)	(0.008)		
HICP_V	−0.293		−0.175	
	(0.246)		(0.252)	
HICP_V_alt		−0.231		0.749
		(0.717)		(0.79)
HICP* HICP_V			−0.026 **	
			(0.011)	
HICP* HICP_V_alt				−0.214 **
				(0.255)
Inv	0.194 ***	0.196 ***	0.186 ***	0.196 ***
	(0.061)	(0.062)	(0.059)	(0.06)
XM	0.021 *	0.02 *	0.021 *	0.020 *
	(0.011)	(0.011)	(0.012)	(0.011)
Debt	0.038 ***	0.037 ***	0.038 ***	0.035 ***
	(0.012)	(0.012)	(0.012)	(0.011)
LTIRs	−0.555 ***	−0.584 ***	−0.572 ***	−0.605 ***
	(0.077)	(0.093)	(0.082)	(0.093)
Observations	627	627	627	627
Countries	27	27	27	27
R-squared	0.654	0.651	0.655	0.653
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Note: This table presents the estimation results for the non-linear models described in Equations (2) and (3). Robust standard errors are reported in the parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% levels, respectively.

Overall, the results from both linear and non-linear specifications did not succeed in identifying a robust negative relationship between inflation or inflation volatility and economic growth for EU economies during the period 2000–2023.

5. Robustness Checks

To ensure the consistency of the previous findings, several robustness tests were conducted by employing different estimation techniques, both static and dynamic. To address potential cross-sectional dependence, regressions were performed using Driscoll and Kraay (1998) standard errors. In this framework, the residuals are assumed to be heteroskedastic, autocorrelated up to some lag, and correlated between panels, making it applicable to unbalanced panels.

To mitigate potential endogeneity issues, the Generalized Method of Moments (GMM) estimator developed by Arellano and Bond (1991) was employed in both static and dynamic frameworks. The lagged values of the explanatory variables (Barro & Sala-i-Martin, 2003) are utilized as instruments along with the log of population size (Boone, 1996; Dalgaard et al., 2004), which serves to control for the varying sizes of EU countries. Additionally, a political variable, specifically the frequency of government changes within a year (Armingeon et al., 2024), was introduced as an instrument to account for political stability across different EU countries. The presumed exogeneity of government changes is leveraged to effectively address temporal variations in policy shifts unrelated to the specific determinants of economic growth considered in the analysis.

To further exploit the dynamic dimension of the relationship between inflation, inflation volatility, and growth, the bias-corrected least squares dummy variable (LSDVC) estimator using the Anderson–Hsiao estimator and Monte-Carlo experiments (Kiviet, 1995) is also employed[7]. More specifically, to resolve the endogeneity bias issue, we followed the instrumental variable developed by Anderson and Hsiao (1982) within an estimator consistent with the coefficients of the time-varying covariates.

It should be noted that in the baseline regressions, interest rates consistently demonstrate a significant relationship with growth. Therefore, interest rates are retained as additional control variables in the regressions, which are conducted as part of the robustness checks.

The results of the robustness tests (Table 3) are consistent with the baseline results regarding inflation rate and interest rates. A statistically significant negative relationship between economic growth and the inflation rate is not observed in most cases. On the contrary, in the GMM and LSDVC models, the inflation rate seems to be positively correlated with economic growth. This result is consistent with explanations that consider inflation to be beneficial for investment and thus positively correlated with growth (Pollin & Zhu, 2006; Zhou, 2019; Huang et al., 2021; Yilmazkuday, 2021). On the other hand, inflation volatility turned out to have a negative impact on economic growth. Moreover, interest rates show a consistently significant negative association in all cases. Regarding the remaining control variables, investment seems to be the variable that is systematically positively associated with GDP growth.

Finally, to control whether the participation of an EU country in the European Monetary Union (EMU) influences growth and may alter the previous results, a dummy variable is constructed and introduced into various models (Table 4). The dummy variable, denoted as "EMU", takes the value of one for the year in which a European country joins the EMU and zero otherwise.

Table 3. Robustness checks.

Dependent: GDP_C	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	Driscoll–Kraay		**GMM**		**Dynamic GMM**		**LSDVC**	
Constant	0.835	0.973	-	-	14.29 **	4.432	-	-
	(3.110)	(3.140)	-	-	(6.23)	(6.162)	-	-
HICP	−0.098	−0.137	0.569 ***	0.378 ***	0.814 ***	0.483 ***	0.321 ***	0.133 *
	(0.070)	(0.088)	(0.125)	(0.110)	(0.186)	(0.164)	(0.071)	(0.067)
HICP_V	−0.338 **		−1.093 ***		−1.359 ***		−0.828 ***	
	(0.131)		(0.188)		(0.271)		(0.145)	
HICP_V_alt		−0.233		−5.344 ***		−8.905 **		−2.296 ***
		(0.695)		(1.935)		(3.274)		(0.858)
Inv	0.195 **	0.200 **	0.075	0.119	−0.229	0.13	0.114 *	0.137 **
	(0.081)	(0.084)	(0.138)	(0.107)	(0.191)	(0.159)	(0.063)	(0.064)
XM	0.021 *	0.019 *	0.001	−0.006	−0.022	0.003	0.012	0.002
	(0.011)	(0.011)	(0.012)	(0.013)	(0.014)	(0.016)	(0.010)	(0.010)
Debt	0.037 *	0.035 *	−0.028	−0.046	−0.048 *	−0.004	−0.006	−0.010
	(0.018)	(0.019)	(0.021)	(0.030)	(0.025)	(0.029)	(0.012)	(0.012)
LTIRs	−0.552 ***	−0.588 ***	−0.415 ***	−0.584 ***	−0.575 ***	−0.455 **	−0.330 ***	−0.402 ***
	(0.173)	(0.184)	(0.123)	(0.137)	(0.146)	(0.17)	(0.089)	(0.091)
Dependent (t − 1)					0.025	0.131	0.092 **	0.150 ***
					(0.08)	(0.086)	(0.042)	(0.042)
Observations	627	627	627	627	609	609	628	628
Countries	27	27	27	27	27	27	27	27
Adj. R-squared	0.653	0.649	-	-	-	-	-	-
Hansen J statistic (*p*-value)	-	-	0.99	0.99	0.785	0.77	-	-
Instruments	-	-	202	202	41	41	-	-
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	-	-

Note: Robust standard errors are reported in parentheses in specifications (3)–(6). Driscoll–Kraay standard errors are reported in parentheses in specifications (1) and (2). Bootstrapped standard errors based on 100 replications are reported in parentheses for specifications (7) and (8), respectively. ***, **, and * denote statistical significance at the 1, 5, and 10% levels, respectively.

The introduction of the EMU variable did not significantly change the previous results. The inflation rate remained either statistically insignificant or a positive determinant of GDP per capita growth in all specifications. Inflation volatility shows in some cases a significant and negative correlation with growth. The EMU dummy is statistically significant and negatively related to growth in all cases, implying that joining the euro area has a negative impact on the growth rate of EMU member countries. Regarding long-term interest rates, there is consistently a statistically significant negative impact on GDP growth in EU economies.

Table 4. Robustness checks with EMU dummy variable.

Dependent: GDP_C	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
	Linear FE		**Non-Linear FE**		**Driscoll–Kraay**		**GMM**		**Dynamic GMM**		**LSDVC**	
Constant	2.447 (2.24)	2.618 (2.317)	2.3 (2.325)	2.192 (2.371)	2.447 (3.308)	2.618 (3.362)	- -	- -	18.733 (11.313)	4.663 8.399		
HICP	−0.083 (0.088)	−0.12 (0.111)	−0.041 (0.154)	−0.012 (0.166)	−0.083 (0.071)	−0.120 (0.085)	0.544 *** (0.133)	0.406 *** (0.114)	1.12 *** (0.241)	0.415 *** (0.141)	0.341 *** (0.070)	0.159 ** (0.066)
HICP^2			−0.003 (0.007)	−0.01 (0.008)								
HICP_V	−0.377 (0.247)		−0.353 (0.253)		−0.377 *** (0.111)		−1.145 *** (0.227)		−2.131 (0.395)		−0.836 *** (0.142)	
HICP_V_alt		−0.433 (0.644)		−0.427 (0.641)		−0.433 (0.650)		−7.101 *** (2.224)		−7.949 ** (3.055)		−2.524 *** (0.847)
Inv	0. 164 *** (0.053)	0.169 *** (0.058)	0.163 *** (0.053)	0.167 *** (0.055)	0.164 * (0.084)	0.169 * (0.087)	−0.095 (0.115)	−0.074 (0.151)	−0.471 (0.312)	0.048 (0.234)	0.052 (0.063)	0.074 (0.064)
XM	0.025 * (0.013)	0.023 * (0.012)	0.025 * (0.013)	0.024 * (0.013)	0. 025 ** (0.012)	0.023 * (0.011)	0.047 ** (0.021)	0.046 * (0.027)	0.019 (0.023)	0.029 * (0.015)	0.023 ** (0.010)	0.013 (0.010)
Debt	0.034 *** (0.012)	0.033 ** (0.012)	0.035 *** (0.012)	0.034 *** (0.012)	0.034 * (0.018)	0.033 * (0.019)	−0.045 (0.030)	−0.062 (0.042)	0.004 (0.035)	0.023 (0.028)	−0.011 (0.012)	−0.015 (0.012)
LTIRs	−0.602 *** (0.108)	−0.638 *** (0.131)	−0.603 *** (0.11)	−0.634 *** (0.131)	−0.602 *** (0.174)	−0.638 *** (0.186)	−0.562 *** (0.152)	−0.676 *** (0.206)	−0.583 ** (0.244)	−0.44 ** (0.168)	−0.431 *** (0.089)	−0.506 *** (0.092)
EMU	−1.806 * (0.958)	−1.756 * (0.924)	−1.786 * (0.959)	−1.714 * (0.914)	−1.806 *** (0.576)	−1.756 ** (0.641)	−9.402 ** (4.168)	−8.179 *** (3.047)	−10.351 *** (2.064)	−6.106 * (3.345)	−3.583 *** (0.822)	−3.650 *** (0.850)
Dependent (t − 1)									−0.115 (0.441)	0.105 (0.11)	0.067 * (0.041)	0.127 *** (0.041)
Observations	627	627	627	627	627	627	627	627	609	609	628	628
Countries	27	27	27	27	27	27	27	27	27	27	27	27
Adj. R-squared	0.664	0.660	0.664	0.661	0.664	0.659	-	-	-	-	-	-
Hansen J statistic (*p*-value)	-	-	-	-	-	-	0.99	0.99	0.764	0.732	-	-
Instruments	-	-	-	-	-	-	202	202	41	41	-	-
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-

Note: Robust standard errors are reported in parentheses for specifications (1)–(4) and (7)–(10). Driscoll–Kraay standard errors are reported in parentheses in specifications (5) and (6). Bootstrapped standard errors based on 100 replications are reported in parentheses for specifications (11) and (12), respectively. ***, **, and * denote statistical significance at the 1, 5, and 10% levels, respectively.

6. Short Discussion

Bernanke et al. (1997) examined the role of monetary policy in postwar U.S. business cycles, focusing primarily on oil price shocks that resulted in higher inflation rates. The central question addressed in this study was whether oil price shocks were the primary drivers of U.S. recessions or whether monetary tightening was the major cause of economic downturns. Their research revealed that the output response is inversely correlated with the FED rate response. The sharpest decline in output occurred during the period 1976–1985, when monetary tightening was the most aggressive, presumably reflecting the Federal Reserve's increased concern with inflation during the Volcker regime. Thus, a substantial part of the impact of oil price shocks on the economy resulted not from the change in oil prices per se, but from the resulting tightening of monetary policy. More recently, Khan (2022) challenged the view that inflation targeting should not be seen as a panacea for chronic macroeconomic ills. He finds that the average growth rate is significantly lower in inflation-targeting countries, by more than half a percentage point, than in non-inflation-targeting countries. In addition, long-term unemployment rises significantly in inflation-targeting countries, by more than 1½ percentage points, compared to non-adopters.

The recent global inflationary episode, which spurred inflation in European economies, prompted the ECB to sharply increase interest rates to steer the European inflation rate towards the two percent target. However, as indicated by the results of this study, this path may come at a cost to European Union economies in terms of growth, potentially sacrificing foregone growth during the stabilization process. Notably, the growth rates of the EU-27 and EZ-20 economies experienced a sharp decrease, from 3.4% in 2022 to 0.4% in 2023, with high interest rates potentially contributing to this steep decline. This does not necessarily imply that the ECB should adopt a stance of inaction, as proposed by DeLong (2023), who suggests that the current episode of inflation might be economic remobilization. Other proposals, such as those advocating for a higher inflation target of around 4% (see, e.g., Blanchard et al., 2010; Ball, 2014; Krugman, 2014), could provide the ECB with more room for maneuvering, to avoid the prolonged preservation of high interest rates. The findings of this study may support this argument because no robust evidence was found that inflation rate has a direct negative impact on the economic growth of EU economies[8]. Therefore, a reduction in the ECB's interest rates may be a remedy for better gross domestic product growth performance in EU economies in the coming period.

7. Conclusions

This study investigated the relationship between inflation, inflation volatility, and economic growth in European Union economies from 2000 to 2023. The results indicate that inflation did not demonstrate a consistent negative impact on gross domestic product growth during the examined period. None of the specifications showed a negative and statistically significant relationship between inflation and growth. By contrast, in instances where the relationship between inflation rate and growth was found to be statistically significant, the sign was positive, indicating a positive link between these two variables. Moreover, there is some evidence suggesting that inflation volatility negatively affects growth. Notably, the research highlights a persistent negative association between high interest rates and economic growth in EU countries, providing crucial insight into the potential risks associated with aggressive monetary tightening.

The findings of this study call for careful consideration of policy choices, particularly in balancing inflation control against the imperative to promote economic growth. As the European Central Bank addresses the challenges posed by inflationary pressures, this study argues for a prudent and flexible approach to monetary policy. The observed slowdown in gross domestic product growth rates in 2023 following significant interest rate

hikes underscores the importance of nuanced decision making by monetary authorities. Moreover, recent discussions on the European Central Bank's (ECB's) neutral interest rate suggest that a gradual move towards this level may be more conducive to sustainable economic growth than the tight monetary policy of higher interest rates. This research contributes to the ongoing discourse on the ECB's policy considerations regarding its key interest rates and possible alignment with proposals for a higher inflation target. Such an approach could provide the ECB with greater maneuverability and help mitigate the adverse effects of prolonged high interest rates on EU economies by allowing a moderately higher rate of inflation than targeted.

The present study is based on the analysis of data on the relationship between inflation and economic growth in EU economies after the creation of the single European currency, a topic that has not been extensively studied. We believe that the results shed light on this particular relationship in Europe after the creation of the single currency. However, there are limitations and considerations that need to be taken into account. One limitation is that we have considered only one measure of inflation: the Harmonized Index of Consumer Prices (HICP). While this measure is widely used for data analysis, other important aspects of inflation could be examined in future research. For example, it would be valuable to examine how different types of inflation (e.g., public spending inflation, supply inflation, imported inflation) affect growth in EU economies. In addition, the time span selected for the present study (2000–2023) includes periods of both low and high inflation. However, specific types of inflation, such as creeping and galloping inflation, could also be considered for further study using threshold regression models.

Furthermore, our study has limitations when considering certain macroeconomic and political forces affecting the European Union and the institutional role of the European Central Bank (ECB). For example, the reason why the high inflation rate does not seem to have a negative impact on the growth of EU economies could be attributed to the existence of the ECB, which in a way guarantees a moderate inflation rate and a low inflation volatility for EU economies. Thus, some adverse effects of moderate inflation may not be revealed due to the presence of strong institutions such as the ECB. In the same vein, participation in the Economic and Monetary Union (EMU) means that the participating governments are obliged to support their banks, which are members of the Eurosystem, with guarantees (Dantas et al., 2023). In this sense, participation in the EMU has helped to make the economies of its member countries more stable and resilient to inflationary pressures (Agarwal & Baron, 2024), a fact that cannot be captured in this particular study. Moreover, an advantage of the ECB's low-inflation-targeting policy is that it can use an expansionary monetary policy in times of financial turmoil, such as the Global Financial Crisis of 2008 and the Euro Area Debt Crisis of 2010 (Acharya et al., 2014; Verner & Gyöngyösi, 2020), because inflation is generally under control. Otherwise, the ECB could not be very active in easing monetary policy in an environment of moderate or high inflation. Moreover, the ECB's policy of controlling inflation may allow EMU countries to more easily absorb exogenous shocks, such as those from Brexit (Campello et al., 2022) or other disruptions caused by the rise in political populism in Europe (Verner & Gyöngyösi, 2020). EU economies are characterized by strong institutional features due to the existence of the EMU. These features may have fostered economic growth in ways that cannot be derived directly from this study. Therefore, the results should be interpreted with some caution, as they may not fully capture the complexity of inflation dynamics in different contexts or periods. With this caveat in mind, further research may be needed to explore features not captured by our analysis. Future research could address these limitations by examining the impact of inflation on economic growth in different regions and over different time periods. For example, studies could focus on Latin American countries,

which have experienced more frequent and severe inflationary shocks, to see whether the findings hold in a different context.

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Appendix A

Table A1. Description of variables.

Variable Name	Definition	Source
Dependent variable		
GDP_C	Gross domestic product at market prices—chain-linked volumes, percentage change on previous year, per capita	Eurostat
Independent variables		Eurostat
Inflation (HICP)	Harmonized Index of Consumer Prices (HICP)—annual average rate of change	Eurostat
Inflation Volatility (HICP_V)	The moving averages of the standard deviation of year-on-year inflation rates over the last three-year period	Own calculations
Inflation Volatility 2 (HICP_V_alt)	The moving averages of the standard deviation of the intra-year monthly inflation rate over 12 months	Own calculations
Fixed Investments to GDP (Inv)	Gross fixed capital formation, percentage of gross domestic product (GDP)	Eurostat
Trade Openess (XM)	Total trade (sum of imports and exports) as a percentage of gross domestic product (GDP), in current prices	Eurostat
Gross Debt/GDP (Debt)	General government gross debt as a share of gross domestic product (GDP)	Eurostat
Long-term interest rates (LTIRs)	The 10 year government bond yield. Average value. European Monetary Union (EMU) convergence criterion	Eurostat
Credit expansion (Credit)	Total credit to private non-financial sector. Percent change from year ago	Federal Reserve Bank of St. Louis
Public expenditures to GDP (GG)	Total expenditures of general government as a percentage of gross domestic product (GDP)	Eurostat
R&D activities to GDP (R&D)	The value of R&D activities for all sectors of the economy as percentage of gross domestic product (GDP)	Eurostat
Education level (Edu)	Upper secondary and post-secondary non-tertiary education (levels 3 and 4). Percentage of total population, from 15 to 64 years	Eurostat
Institutions	The sum of the scores of the six governance indicators of the World Bank: Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, Voice and Accountability	Worldwide Governance Indicators, World Bank
Instrumental variables		
Population growth	The logarithm of the population size as of January 1st	Eurostat
Government change	A variable that assigns a value of one each time there is a change in government within a year. Government changes are considered when any of the following occurs: (a) elections, (b) voluntary resignation of Prime Minister, (c) resignation of Prime Minister due to health reasons, (d) dissension within government (break up of the coalition), (e) lack of parliamentary support, (f) intervention by the head of state, and (g) broadening of the coalition through the inclusion of new parties	Armingeon et al. (2024)

Table A2. Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) GDP_C	1.000														
(2) HICP	0.159 *	1.000													
(3) HICP_V	−0.022	0.675 *	1.000												
(4) HICP_V_alt	−0.135 *	0.195 *	0.203 *	1.000											
(5) Debt	−0.247 *	−0.216 *	−0.129 *	0.365 *	1.000										
(6) Inv	0.244 *	0.209 *	0.030	−0.221 *	−0.471 *	1.000									
(7) XM	0.077	−0.014	0.042	0.273 *	−0.273 *	−0.037	1.000								
(8) LTIRs	−0.118 *	0.228 *	0.180 *	0.091 *	0.050	−0.029	−0.231 *	1.000							
(9) Credit	0.178 *	0.108 *	−0.116 *	−0.164 *	−0.234 *	0.237 *	−0.014	0.160 *	1.000						
(10) GG	−0.426 *	−0.182 *	−0.140 *	−0.012	0.521 *	−0.303 *	−0.339 *	−0.010	−0.138 *	1.000					
(11) R&D	−0.238 *	−0.174 *	−0.186 *	−0.205 *	0.102 *	−0.028	−0.155 *	−0.380 *	−0.086 *	0.607 *	1.000				
(12) Edu	0.191 *	0.163 *	0.179 *	−0.413 *	−0.349 *	0.213 *	−0.141 *	0.087 *	0.057	−0.080 *	−0.068	1.000			
(13) Institutions	−0.178 *	−0.255 *	−0.252 *	−0.099 *	−0.087 *	−0.001	0.234 *	−0.367 *	0.065	0.254 *	0.663 *	−0.301 *	1.000		
(14) Lpop	−0.101 *	0.006	−0.066	−0.226 *	0.376 *	−0.066	−0.686 *	0.036	−0.037	0.347 *	0.266 *	0.085 *	−0.104 *	1.000	
(15) Gov_chan	−0.011	0.005	0.052	−0.074	−0.009	0.058	−0.097 *	0.071	−0.042	0.043	−0.034	0.103 *	−0.086 *	0.079	1.000

Note: * denotes statistical significance at maximum level of significance of 5%.

Table A3. Variance inflation factor.

	VIF	1/VIF
R&D	3.69	0.271
Debt	3.406	0.294
GG	2.874	0.348
Institutions	2.817	0.355
XM	2.666	0.375
Lpop	2.666	0.375
HICP_V_alt	2.108	0.474
HICP	1.858	0.538
LTIRs	1.694	0.59
Inv	1.683	0.594
Edu	1.654	0.605
HICP_V	1.522	0.657
Credit	1.225	0.816
Gov_chan	1.041	0.96
Mean VIF	*2.208*	

Note: This table shows the Variance Inflation Factor (VIF) values for the predictor variables. The VIF values measure the extent of multicollinearity among the predictor variables in the regression model. A VIF value greater than 10 typically indicates high multicollinearity, which can affect the stability and interpretation of the regression coefficients. In our analysis, all VIF values are below 10, with a mean VIF of 2.21, indicating no serious multicollinearity issues. The 1/VIF values (tolerance values) are the reciprocal of the VIF values. In our results, the tolerance values are all above 0.1, further confirming that multicollinearity is not a significant concern in our models. Overall, these results suggest that the predictor variables are sufficiently independent of each other, allowing for the reliable estimation of the regression coefficients and valid interpretation of the model.

Notes

1 See for instance Phillips (1962), Sidrauski (1967), Thirlwall and Barton (1971), and Dornbusch and Frenkel (1973).

2 The sample used in this study has only one observation of inflation above 40% annually out of 643 observations. In this manner, the concern raised by Bruno and Easterly (1998), suggesting that the negative correlation between inflation and economic growth is attributed to hyperinflation episodes, is overcome.

3 Our sample comprises all EU economies, regardless of whether they have adopted the euro. The research operates under the assumption that the European Central Bank's (ECB's) monetary policy significantly influences EU countries that do not participate in the Economic and Monetary Union (EMU). However, the results are also controlled specifically for EMU countries.

4 The inclusion of both the inflation rate and inflation volatility in the same regression may raise concerns about potential multicollinearity problems. However, as shown in Tables A2 and A3, the correlation between the variables is quite low, indicating that a serious multicollinearity problem is not present. Additionally, separated regressions were run one with inflation and another one with inflation volatility instead of putting these two variables in a single regression. Due to space considerations, these results are not presented; however, they are available upon request.

5 Robust standard errors are employed to address any potential heteroskedasticity and autocorrelation in the residuals.

6 The additional control variables were also examined following the methodology of linear specifications. The results remained consistent even when the supplementary control variables were introduced to the non-linear models. Due to space considerations, these results are not presented; however, they are available upon request.

7 The study employs the dynamic GMM specification and the LSDVC estimator to avoid the Nickell bias (Nickell, 1981) that may arise when running a dynamic fixed effects panel regression, especially in this case where the number of cross-sections is larger than the time dimension. Including a lagged dependent variable in a panel framework can result in biased and inconsistent estimates due to the autocorrelation introduced by its correlation with the unobserved heterogeneity component.

8 While the indirect negative impact of inflation is also not profound, as evidenced by Nakamura et al. (2018), who found little evidence that the Great Inflation of the late 1970s and early 1980s led to a substantial increase in price dispersion, which is considered one of the major costs of inflation.

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